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POTATO PRODUCTION

IN THE SOUTHERN STATES

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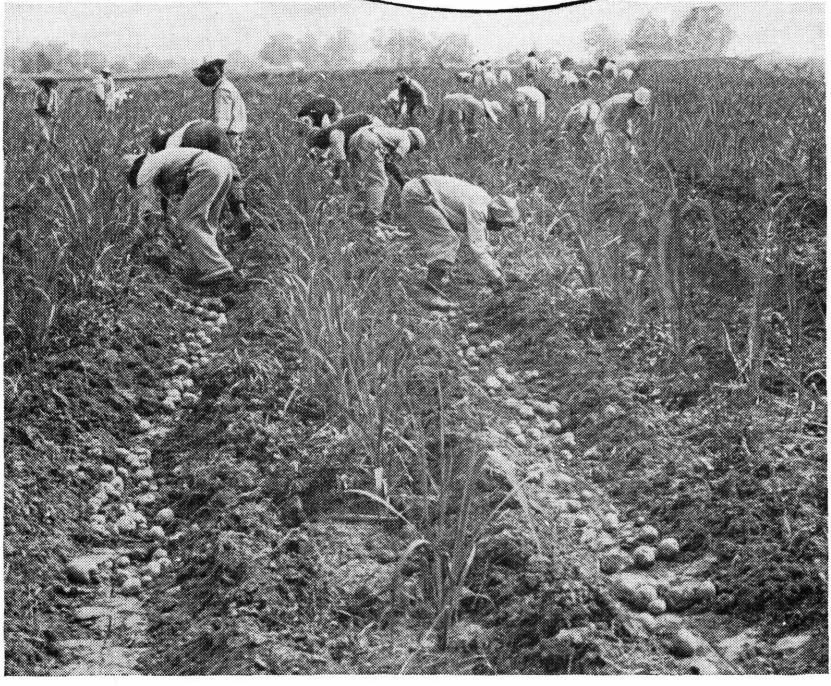
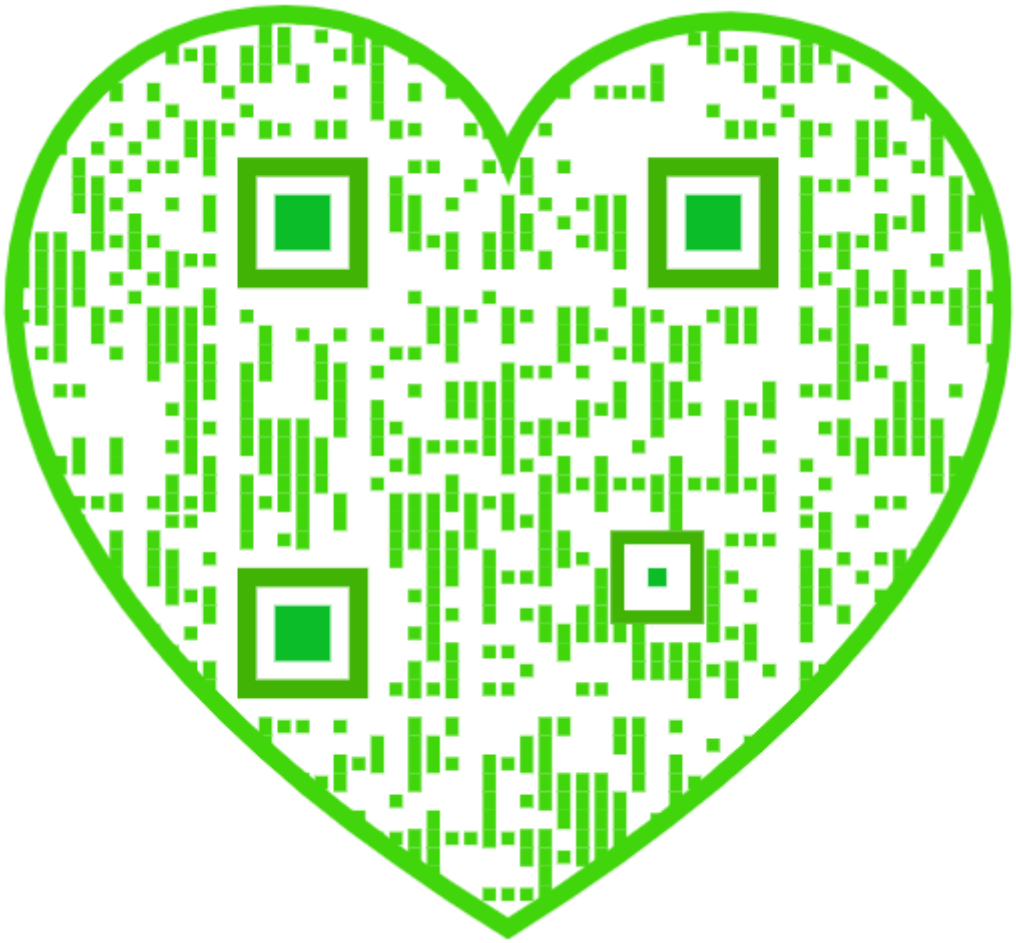


FARMERS' BULLETIN No. 1904
U. S. DEPARTMENT OF AGRICULTURE



THE POTATO is one of the most important staple food crops in the South. As many changes have taken place in the potato industry in this region during the past 15 to 20 years, it is important for growers to be familiar with changes in methods of production and marketing and with the new varieties being developed. Side placement of fertilizers results in increased yields as compared with those resulting from various other methods of application. The potato industry of the South could be materially improved by adopting a system of crop rotation that would insure the addition of a larger amount of organic matter to the soil. The use of certified seed is coming to be a standard practice in many of the larger commercial areas of the South, and in certain States certified seed is being produced. Methods of seed treatment are described briefly. Washing is rapidly becoming a common practice in many of the potato-producing sections.

New varieties resistant to certain diseases, briefly discussed herein, have already been released and are grown commercially. These new varieties are Warba, Red Warba, Katahdin, Chippewa, Sebago, Earlaine, Houma, Pontiac, and Sequoia. Insect enemies of potatoes and varieties of potatoes for and problems of the several States making up the southern production region are discussed.

This bulletin supersedes Farmers' Bulletin 1205, Potato Production in the South.

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POTATO [1] PRODUCTION IN THE SOUTHERN STATES

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PRESENT STATUS OF POTATO INDUSTRY

THE POTATO is one of the most important staple food crops grown in the United States. The Southern States produce annually about 15 percent of the total crop of this country. The wide diversity of seasonal conditions in the South and the long growing season make it possible to plant and harvest potatoes in some locality in practically every month of the year. Because of varying climatic conditions, due to both altitude and latitude, there are three distinct seasonal divisions [2] in potato production in the Southern States, namely, the early or spring crop, the late or main crop, and the fall crop.

[1] The name potato, as used in this bulletin, refers to the white or Irish potato rather than to the sweetpotato. The latter is widely termed "potato" in the southern part of the United States.

[2] These seasonal divisions are used for the purpose of the discussions in this bulletin and should not be confused with seasonal divisions used by the Agricultural Marketing Administration for crop reporting purposes.

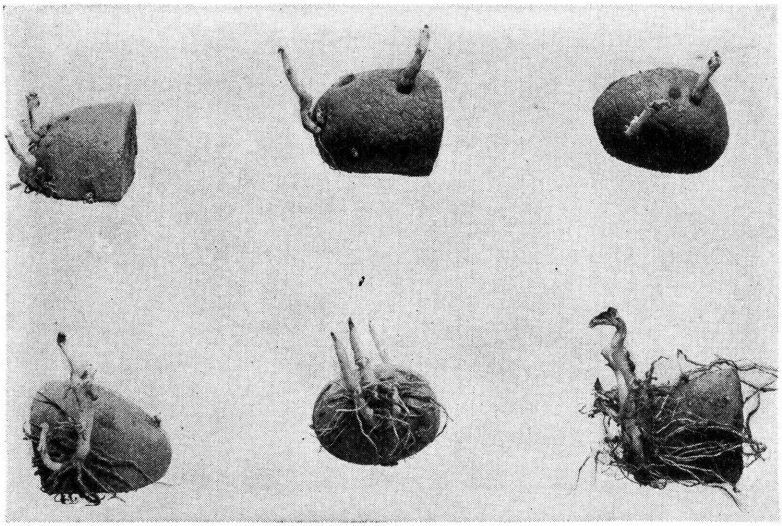

FIGURE 1.—Effect of moisture on sprouting. The seed pieces in the top row were taken from dry soil; those in the lower row from moist soil. All were planted at the same time. Note the formation of roots on the lower seed pieces only.

For purposes of this bulletin the following States are considered as making up the southern production region: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

CLIMATE

As the potato is a cool-climate plant, a moderate temperature is necessary for its best growth. Therefore, early-spring planting usually assures that the crop will be well established before the period of high temperatures.

In most years, rainfall in the Southern States is sufficient for the production of the early and main crops. In nearly all areas the fall crop would be materially benefited if irrigation water could be applied at critical periods during the growth of the plant (fig. 1). The ideal condition is a uniformly ample supply of soil moisture throughout the growing season. This is especially important from the time tubers begin to form until shortly before harvest. Adequate moisture at the time of tuberization plays an important role in determining the number of tubers formed, or the set. Uniform moisture after tuber formation is an important factor in determining the development of tubers, especially their size, smoothness, and shape.

SOIL

The choice of soil for potato growing is very important because soil influences both growth and yield. Well-drained, friable loams and sandy loams are well suited for potato production because they generally yield brighter skinned and better shaped tubers. Generally

speaking, the early potato crop is grown in sections where the soils are predominantly loams and light sandy loams, because these types of soils warm up faster than do the heavier types. The heavier soils, such as clays and clay loams, are more difficult to prepare and often tend to puddle in periods of high rainfall if worked at the wrong time. Such soils are much better adapted to other field crops.

PREPARATION OF SEEDBED

Deep plowing is essential, as it provides adequate depth of soil for root development. Since most of the potato root system is confined to the upper foot of soil, if practicable, plowing should be to a depth of at least 8 to 10 inches; the depth, however, must be governed by that of the surface soil. A good rule is never to turn up more than an inch of subsoil at any one time. The plowing should be done sufficiently in advance of the planting date to permit partial decomposition of the vegetable matter, such as soybeans, cowpeas, cornstalks, or other preceding crops that have been turned under. The usual practice is to plow the soil into rather narrow ridges or beds (fig. 2). This insures better drainage and consequently permits an earlier preparation of the seedbed.

A few days prior to the planting of the crop the land should be thoroughly fitted by the use of a disk or a cutaway harrow. As a rule land that is lumpy or filled with coarse, undecayed organic matter will not produce as large a crop as soil that is in a loose, friable condition and in which the organic matter is fairly well decomposed.

FIGURE 2.—Preparation of ridges or beds by use of two middle-breaker plows.

FERTILIZATION PRACTICE

COMMERCIAL FERTILIZERS

Considerable nutrient material, particularly nitrogen and potassium compounds, is removed from the soil by potato plants. In addition, heavy losses from leaching are apt to occur under the high-rainfall conditions existing over a large portion of the South. In order to maintain high-level yields, such losses must be replaced by the application of fertilizers and any available stable manure.

The quantity of fertilizer needed depends both on the amount of manure, if any, used in the rotation and on the frequency and rate of application of fertilizer used on previous crops in the rotation. A number of mixtures are used in the South, chiefly 4–8–4, 4–8–6, 4–10–7, 4–12–4, 6–6–5, 6–8–4, and 6–8–6. The rates of application range from 600 to 2,000 pounds to the acre for the early and main crops.

The customary method of applying fertilizer in the South is to open a furrow with a middle-breaker plow or a turnplow a week or 10 days before planting, distribute a portion of the fertilizer in the furrow thus made, and then mix it thoroughly with the soil. Horse-drawn planters with fertilizer-distributing attachments are being used in some of the larger commercial districts of the South.

Recent investigational work in North Carolina, Virginia, Michigan, Ohio, New Jersey, New York, and Maine has demonstrated that side placement of fertilizer (fig. 3) results in increased yields as compared with various other methods of application. Best results have been

FIGURE 3.—Effect of side placement of commercial fertilizer on growth of potatoes: *A*, Applied in bands 4 inches to each side, at level of seed piece; *B*, mixed with soil and mostly placed under seed piece; *C*, applied in bands 2 inches to each side, at level of seed piece.

FIGURE 4.—Plowing under a green-manure crop to improve the organic-matter content of the soil.

obtained by placing the fertilizer in bands about 2 inches to each side and practically level with the seed pieces. Side placement of fertilizer has been adopted as a fertilizer practice by many potato growers along the Atlantic seaboard from Maine to Florida. Horse- or tractor-drawn potato planters equipped with either single- or multiple-row fertilizer depositors are now available on the market. These machines usually have a pair of single-disk furrow openers that are adjustable for placing the fertilizer in the proper position and at the desired depth in the soil.

BARNYARD MANURE

Where barnyard manure is available, it is recommended that it be broadcast on the land at the rate of 6 to 8 tons to the acre previous to plowing. Such an application should be supplemented with a commercial fertilizer applied in accordance with recommended methods of fertilizer placement. Barnyard manure in itself is not a well-balanced plant food, being too rich in nitrogen for its phosphorus content and inducing a rank vine growth at the expense of tuber development. Generally this can be overcome by adding 50 to 75 pounds of superphosphate to the ton of manure.

Specific fertilizer recommendations for each district can be obtained from the county agricultural agent or the State agricultural experiment station.

CROP ROTATION

Generally speaking, no definite system of crop rotation is practiced in any of the leading commercial potato-producing districts in the South. A rotation is ordinarily desirable in successful potato production because it insures the addition of organic matter to the soil and tends to lessen the severity of certain soil-borne diseases. Planting soybeans or cowpeas previous to planting potatoes is recommended, because these crops produce a large quantity of vines, which, when turned under (fig. 4), materially increase organic matter and maintain the soil in good tilth.

The rotation to adopt will depend largely on the type of farming followed. Where potatoes are the principal crop, a short rotation such as 1 year in legumes and 2 years in potatoes will give fairly satisfactory returns. On farms where other crops take a more important place, the rotation may be lengthened to include 1 year of corn and 2 or 3 years of legumes or other crops.

The practice of growing potatoes continuously in the same field for extended periods makes it difficult to maintain the organic matter in the soil at a satisfactory level except in the early-crops sections, where a summer legume may be grown in the same year following the potato crop. When continuous potato growing is practiced, the principal way to help maintain soil organic matter is to make regular use of cover crops, particularly previous to the potato crop.

As a rule, the potato industry of the South could be materially improved by adopting a system of crop rotation that would insure the addition of a larger amount of organic matter to the soil.

IMPORTANCE OF GOOD, ESPECIALLY CERTIFIED, SEED

The quality of the seed planted is one of the most important factors in the production of profitable potato crops. During recent years considerable attention has been given to the use of good seed, and the indications are that this matter will receive still greater attention in the future. Good seed tubers should be as free from disease as possible, free from varietal mixtures, of high yielding ability, and reasonably uniform in shape and size.

A large portion of the seed stock used in planting the early and main crops in the South is purchased from growers in the North. The use of northern-grown seed is desirable, because in most sections of the South it is not possible to produce seed stock having the same yielding ability and freedom from disease as that grown in the North.

The use of certified seed is coming to be a standard practice in many of the larger commercial districts of the South. Certified seed is inspected at least twice in the field for the purpose of noting the number of varietal mixtures and the presence or absence of diseased plants. If the percentage of mixtures or of any of the transmissible diseases exceeds a certain minimum tolerance, the field is rejected. An examination of the harvested tubers in the bin completes the inspection; if the stock is found to conform to all requirements it is certified. All certified seed stock when put up for shipment has certification tags issued by the State inspection agency.

CUTTING AND CURING SEED

Cut seed is used for planting practically all of the early and main potato crops in the South. On the other hand, small, whole tubers are used for planting the fall crop.

Care should be taken that each seed piece has at least one eye. The size and the shape of seed pieces are much more important than is the number of eyes. Under most conditions it is not safe to use pieces measuring less than 1½ by 2 inches or weighing less than 1 to 1½ ounces. Seed pieces should be blocky (fig. 5) rather than wedge-shaped, since they can be handled more easily in the planter.

It is recommended that seed potatoes be cut just before planting. Cut seed pieces that are not planted immediately after cutting should be well healed or suberized in order that a callus (protective cov-

ering) may be formed over the cut surface. This callus tends to prevent seed-piece decay and damage by seed-corn maggot (see p. 36) when planting is done in a cold, wet soil in the spring. The use of whole tubers is recommended for fall plantings.

Healing of the cut surface is favored by holding the cut seed pieces in an atmosphere of relatively high humidity and moderate temperature. The humidity can be maintained by keeping wet bags over the crates of seed pieces. The temperature should not exceed 60° to 65° F., as higher temperatures tend to favor the rotting of seed pieces by storage fungi.

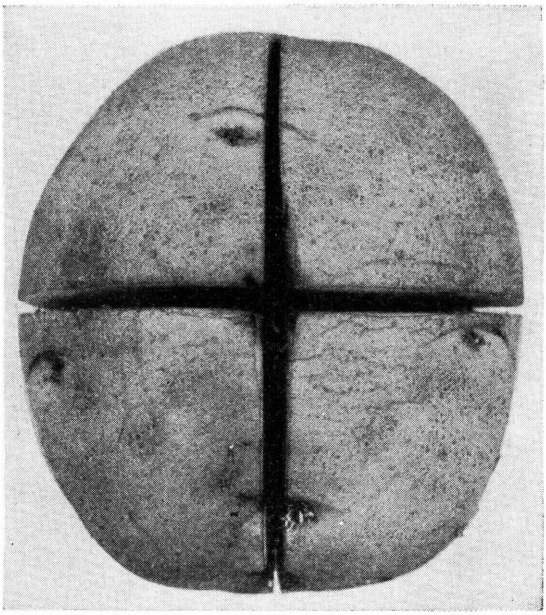

FIGURE 5.—Potato seed cut into blocky pieces rather than thin, wedge-shaped pieces.

SEED TREATMENT WITH DISINFECTANTS

Disinfection of seed potatoes is important in the control of common scab and rhizoctonia canker or black scurf. (See p. 20.) In many of the large production areas of the South seed treatment is a common practice. It should be used wherever either or both of these diseases are prevalent.[3] Any seed that is worth planting is worth treating. The small cost of treating is a good investment and a good form of crop insurance. Seed treatment protects the seed piece and the young plant from injury during early growth and helps insure good stands of vigorous plants. It does not, however, protect the crop against common scab and rhizoctonia canker where the soil is infested with the fungi that cause these diseases.

There are four methods of seed treatment ordinarily available to the grower. The materials used are (1) hot formaldehyde, (2) mercuric chloride, (3) acidulated mercuric chloride (acid-mercury dip), and (4) organic mercury compounds. Prewetting of tubers, if they are not moist when removed from the car, is advisable before treating them with hot formaldehyde or mercuric chloride, as it tends to make the disinfectant more effective in killing *Rhizoctonia*. The standard solutions and period of treatment in use are given below.

HOT FORMALDEHYDE

Formaldehyde, when cold, is irritating to the skin; when heated it will give off vapors irritating to the eyes and respiratory tracts. Oiled

[3] If a prospective grower finds during the present emergency that he cannot obtain either mercury compounds or formaldehyde, for which there are no known substitutes, he will have to weigh the risks of planting potatoes without treating them. He should take special care to obtain seed free of scab and rhizoctonia canker.

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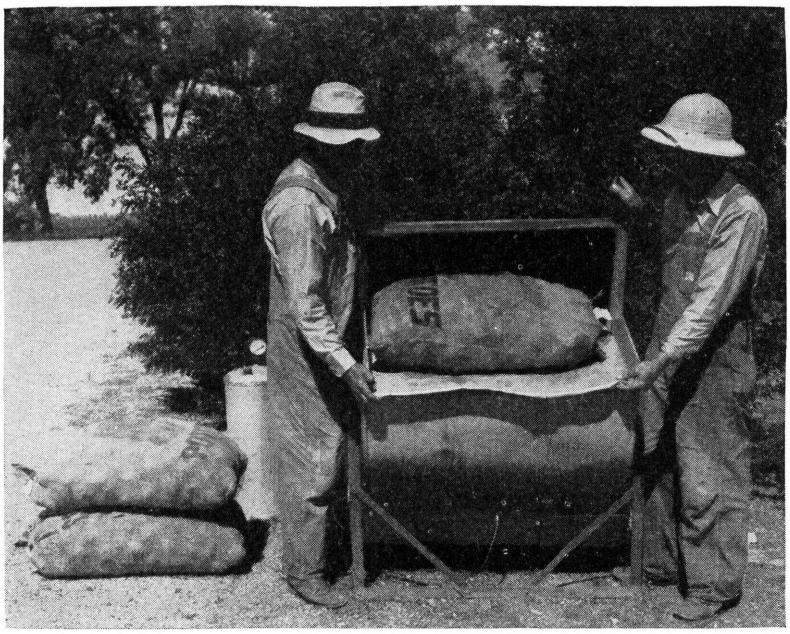

FIGURE 6.—Small outfit for treating potatoes with hot formaldehyde solution on the farm.

leather gloves fitting tightly at the wrist should be worn to prevent harm to the hands. If large quantities of seed are to be treated, a rubber or an oilcloth apron should also be worn to partly protect the clothing. Surplus solution should be buried or otherwise safely disposed of. Vessels and clothing should be thoroughly cleaned. The operation should be carried on out of doors or in a well-ventilated place. If proper ventilation is not possible, a suitable gas mask should be worn by everyone in the room.

The hot formaldehyde method (fig. 6) is best adapted to central-treating-station operation where large quantities of seed are to be disinfected. Of course this method requires the availability of steam so as to maintain a definite temperature of the treating solution. A solution made by mixing commercial 40-percent formaldehyde in water at the rate of 2 pounds (1 quart) to 30 gallons of water is heated to 126° F. and kept between 124° and 126° while the potatoes are being treated. The potatoes are immersed for 4 minutes, then removed, and spread out to dry. This solution does not deteriorate very rapidly and can be used in metal containers; however, it requires considerable skill to avoid injuring the potatoes. Loss of strength, where live steam is used for heating, can be compensated for by adding about 0.9 pint of formaldehyde after every 50 bushels of tubers are treated.

MERCURIC CHLORIDE

Mercuric chloride (also known as bichloride of mercury and corrosive sublimate) solution is generally used at ordinary temperatures and is prepared by dissolving 4 ounces of the chemical in 30 gallons of water. As this material dissolves slowly in cold water, it is better to dissolve the 4 ounces of chemical in 2 or 3 quarts of warm water. This stock

solution is then made up to 30 gallons by the addition of cold water. Since mercuric chloride reacts chemically with metals, thus reducing the effectiveness of the solution and damaging the vessels, it is necessary to use wooden (fig. 7), enamel, or concrete containers. The potatoes should be soaked in this solution 1½ hours. The strength of the solution decreases with use, and it is necessary to add about ½ ounce of the chemical to the treating solution for every 4 or 5 bushels of potatoes treated. After seven or eight lots have been treated, the solution should be discarded and a new one prepared.

As mercuric chloride is a deadly poison, great care must be taken in mixing and handling the solution to prevent any contact with the mouth, eyes, or nostrils. Oiled leather gloves should be worn while mixing and handling the solution, and a rubber or oilcloth apron should be worn to protect the clothing. Unused solution should be buried or disposed of in such a way that human beings and animals cannot be poisoned. All vessels must be thoroughly cleaned before being used again. All clothing and protective devices must be cleaned. Treated potatoes should not be used for cooking or for feeding, nor should livestock be allowed to drink any of the treating solution.

ACIDULATED MERCURIC CHLORIDE (ACID-MERCURY DIP)

The acidulated mercuric chloride (acid-mercury-dip) method is a short-time dip treatment, which reduces the time factor of the preceding method. The treating solution is made by dissolving 6 ounces of mercuric chloride (corrosive sublimate) in 1 quart of commercial hydrochloric acid; this is then added to 25 gallons of water in a wooden container. A 50-gallon wooden barrel is a suitable container. **Concentrated hydrochloric acid is very caustic and should be handled very carefully. In working with acidulated mercuric chloride use**

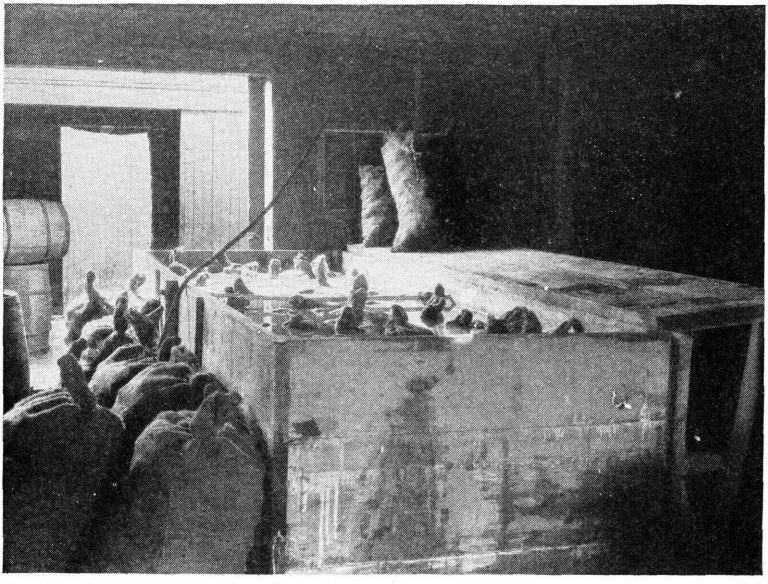

FIGURE 7.—Large wooden tank used for treatment of seed potatoes with mercuric chloride or with acidulated mercuric chloride.

the same precautions suggested with mercuric chloride. (See p. 9.) The tubers should be immersed in the solution for 5 minutes; 20 to 30 sacks can be treated before a new solution is necessary. The tubers should be well dried immediately after being treated; otherwise considerable injury may develop. Cut seed should not be treated by this method.

ORGANIC MERCURY COMPOUNDS

The organic mercury compounds are used as instantaneous dips. These materials are poisonous but not corrosive and can be used in metal containers. The tubers should be thoroughly dried after being treated or else planted immediately. Cut seed may be treated with these materials. **The same precautions should be exercised with organic mercury compounds as with mercuric chloride.** (See p. 9.) The State agricultural experiment stations can advise as to the type of compound to use.

PLANTING

In the South the potato crop is planted either by hand or with a machine. The usual practice in hand planting is to drop the seed pieces in an open furrow (fig. 8), after which they are covered by using a one-mule or two-mule turnplow or a hilling disk to throw a furrow over them from both sides of the row.

Machine planters are used chiefly in the commercial areas where large acreages of potatoes are grown. There are on the market several types of machines, such as one-man machines, two-man machines, one-row planters, and two-row planters. Machine planters are of two types, the mechanical picker and the hand-assisted planter. The type of planter used will depend on the preference of the grower, the acreage, and the amount of help available. The extra cost of the

FIGURE 8.—Opening furrows previous to planting seed pieces.

additional man on the two-man planter is more than repaid by the increased yield resulting from a better stand of plants.

SPACING AND RATE OF PLANTING

The distance between plants and between rows varies considerably. The spacing between plants is usually 12 to 14 inches and the distance between rows may be 30, 32, 36, or 48 inches. In some of the sugarcane areas of Louisiana, potatoes are frequently interplanted with sugarcane in rows 6 feet apart. When rows are less than 30 inches apart the use of a cultivator becomes difficult. Spacing in the row and distance between rows should be such as to obtain a maximum yield of marketable potatoes and at the same time permit horse or tractor cultivation.

The quantity of seed required to plant an acre of potatoes is governed by the weight of the seed piece, the spacing, and the distance between rows. Table 1 gives the quantity of seed necessary to plant an acre at different spacings between rows and between seed pieces with seed pieces of various weights.

TABLE 1.—*Quantity of potatoes required to plant an acre at different spacings with seed pieces of various weights*

Spacing between rows (inches)	Spacing between seed pieces	Seed required when seed pieces of the specified average weight are used—			Spacing between rows (inches)	Spacing between seed pieces	Seed required when seed pieces of the specified average weight are used—		
		1 ounce	1½ ounces	2 ounces			1 ounce	1½ ounces	2 ounces
	Inches	*Bushels*	*Bushels*	*Bushels*		*Inches*	*Bushels*	*Bushels*	*Bushels*
30	8	27.2	40.8	54.4	42	8	19.4	29.1	38.8
	10	21.8	32.6	43.6		10	15.6	23.3	31.1
	12	18.2	27.2	36.3		12	13.0	19.4	25.9
	14	15.6	23.3	31.1		14	11.1	16.6	22.2
32	8	25.5	38.3	51.1	48	8	17.0	25.5	34.0
	10	20.4	30.6	40.8		10	13.6	20.4	27.2
	12	17.0	25.6	34.0		12	11.4	17.0	22.7
	14	14.6	21.9	29.2		14	9.7	14.6	19.4
36	8	22.7	34.0	45.4	72	8	11.3	17.0	22.7
	10	18.1	27.2	36.3		10	9.1	13.6	18.2
	12	15.1	22.7	30.2		12	7.6	11.3	15.1
	14	13.0	19.4	25.9		14	6.5	9.7	12.9

DEPTH OF PLANTING

Since the tuber-producing stolons are formed above the seed pieces, it is important that seed pieces be planted deep enough to permit the development of a good set of tubers. The early crop should not be planted as deep as the main one. A depth of 3 to 4 inches is sufficient for the early crop and 4 to 5 inches for the main crop. The planting should be shallower in heavy than in light soils. Shallow plantings in seasons of dry weather will result in small tubers. On the other hand, in more favorable seasons the tubers in shallow hills will push out of the soil and become sunburned.

The Katahdin variety tends to produce its tubers near the surface of the soil; hence, it is important to keep the soil well ridged around the plants. This will reduce the amount of greening of tubers.

CULTIVATION

Cultivation practice will vary according to the type of soil and the district in which the potatoes are grown. The control of weeds is the principal benefit derived from cultivation.

The first cultivation should be deep and close to the plants. The soil between the rows should be stirred to a depth of 6 inches or more, and every effort should be made to keep it loose. Where ridging is practiced, a turnplow, which draws or throws the soil to the plants, is used.

Subsequent cultivations should be shallower and farther away from the plants, else cutting of roots and a reduction in yield will occur. Cultivation should be repeated as often as may be necessary to keep the soil loose and free from weeds.

If rains follow shortly after planting, the soil should be cultivated as soon as it is dry enough to work. Loose soil at this time will help to prevent suffocation and rotting of the seed pieces.

HARVESTING AND GRADING

The early-potato crop is usually harvested before it is mature, in order to get the higher prices that are generally paid for the new-crop potatoes. Immature potatoes have a thin skin that is easily broken, thus making them very subject to injury when dug; therefore, when possible, digging should be delayed until the plants are fully matured.

Most of the potatoes in the South are dug with a two-horse turnplow and plow-type digger (fig. 9), after which the tubers are picked up and put into containers. On the larger plantings, elevator diggers (fig. 10) have supplanted the small-type diggers.

Mechanical diggers are the cause of a very large percentage of injury. Throwing the tubers into slatted crates is another source of

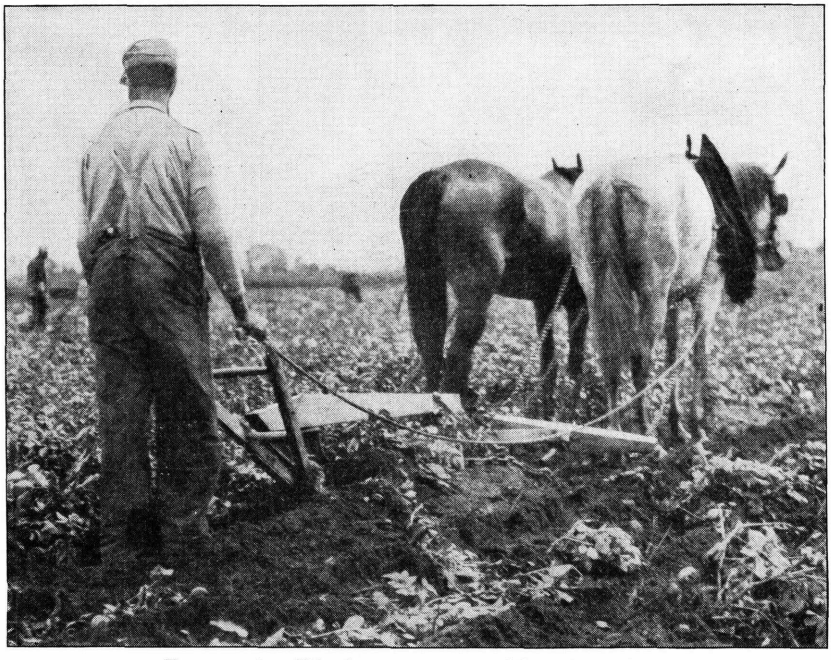

FIGURE 9.—Digging potatoes with a turnplow.

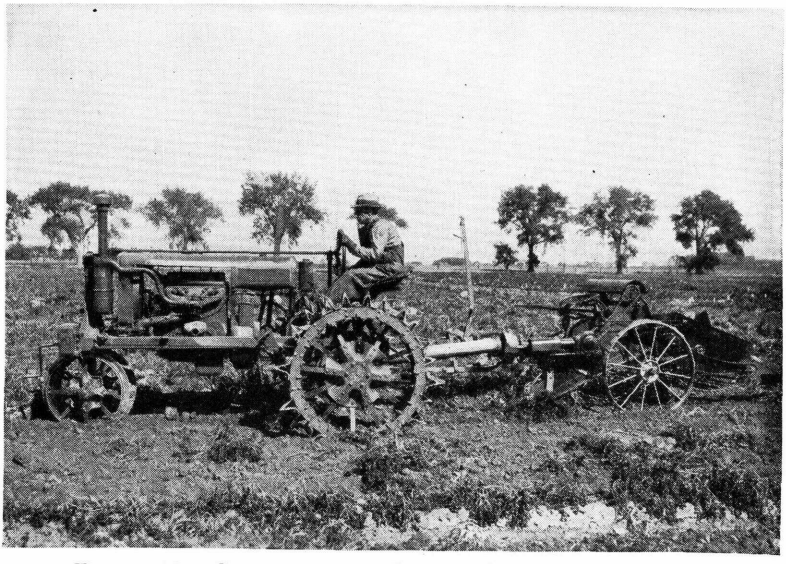

FIGURE 10.—One-row potato digger with a continuous chain.

mechanical injury. Also, a certain amount of injury results from running the potatoes over the grading machine immediately after digging.

A considerable portion of the crop is graded by the pickers while it is being gathered (fig. 11). However, in the commercial areas machine graders are used to a considerable extent.

As a rule, consumers care little about where potatoes are produced, but they demand top grades and attractive packs. Much improvement is yet to be made in the South in the grading and packaging of potatoes.

PREVENTION OF MECHANICAL INJURIES

In general, more attention needs to be given to the prevention of mechanical injuries at the time of harvest. Skinned, bruised, or cut tubers will shrink more rapidly than sound ones. Also, disease-producing organisms may enter injured potatoes and cause decay.

Allowing potatoes to mature before digging will help prevent mechanical injury. Less injury will result if the shaker attachment is covered with rubber hose and the sides with canvas. Reducing the speed of the elevator apron is another way to lessen injury.

Picking baskets and field crates should be lined with burlap. On the market are baskets made of rubberized wire. Freshly dug potatoes should not be thrown or dropped. Care in running potatoes over the grader or sizer will considerably reduce bruising and skinning. It has been found that if the potatoes are allowed to cure in the shade for 24 hours in the crates before they are graded much mechanical injury can be reduced (fig. 12).

STORAGE

Many of the houses used for storing potatoes in the South are insufficiently ventilated and are not built to permit proper regulation of

FIGURE 11.—Picking and field-grading potatoes into wooden crates.

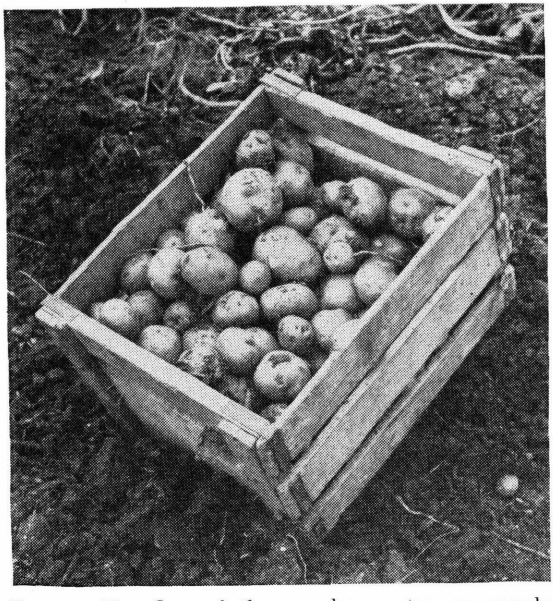

FIGURE 12.—One of the wooden crates commonly used, filled with field-graded potatoes.

temperature. Better storage houses are among the pressing needs of the potato industry in the South. With proper storage facilities it would be possible to keep most, if not all, of the potatoes needed for table use, thus effecting a large saving in transportation charges and commissions. In some sections where sweetpotatoes are grown also, the same storage house and crates are used for both crops.

Storage facilities for seed potatoes are necessary during December, January, and part of February. Losses due to the freezing of seed potatoes could be avoided if proper storage facilities were available during these months.

Storage houses should also be used for carrying over spring-grown seed for planting the following fall. In many districts of the South this is becoming a common practice and permits the growing of enough potatoes in the fall for home use.

Potatoes put into storage should be clean, sound, and mature. Immature tubers with thin or broken skins lose water faster and are more subject to rots than are mature ones. The best tem-

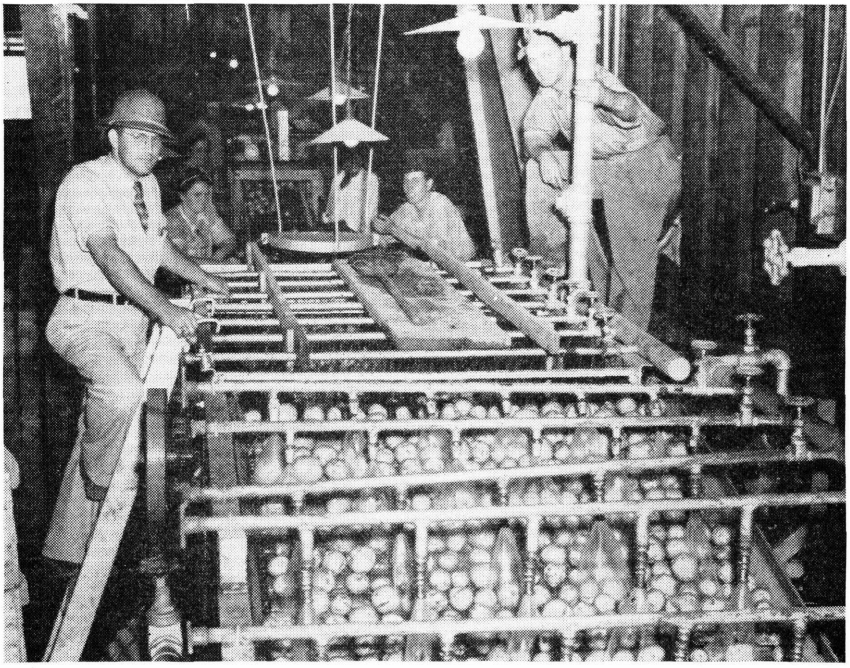

FIGURE 13.—Type of washing machine used for potatoes.

perature for keeping potatoes for an extended period in a healthy, dormant, high-quality condition is between 38° and 40° F. An atmosphere of high relative humidity is also recommended. In Louisiana, the Katahdin variety has been found to be well adapted to storage.

WASHING

The demand for clean potatoes is increasing, and washing is now the general practice with the early crop in Florida, Texas, and Alabama. It is also becoming a common practice with the early crop in Louisiana. More detailed information regarding the different types of washing machines (fig. 13) can be obtained from the State agricultural experiment station or the extension service.

PRODUCTION OF CERTIFIED SEED

The production of certified seed in the South is a relatively new enterprise. Louisiana and Georgia are producing certified seed on a commercial basis. The seed grown in northern Georgia is shipped to the early-producing section of southern Florida. Certified seed is being shipped from Louisiana to Cuba for the winter crop in that country. The production of satisfactory certified seed requires special skill and care. The principal requirements made by State certification services are that the seed shall be true to varietal type and free from disease.

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The certified-seed grower in the South depends on the northern grower for his foundation stock. It is very important that all plantings produced for certification should be grown from best quality foundation stock and should be thoroughly rogued. All parts of the diseased plants that might grow again, including especially the old seed pieces, should be removed from the field. Plants affected with virus and other diseases (see below) should be removed from the field in such way that insects present on them cannot migrate to other plants to which they might transmit diseases. Rogued plants should be placed in a close-mesh sack, which, when filled, should be left at the end of the row for disposal later in the day at a distance not less than 1,000 feet from the field. Every precaution should be taken in disposing of the discarded plants.

More thorough roguing of diseased plants can be obtained if the potatoes are planted as "tuber units." This means planting all the seed pieces cut from a single tuber one after another in the row, with a space separating these from the sets of the next tuber, thus permitting ready and accurate recognition of the different units. In cutting seed for tuber-unit planting it is advisable to partly cut each tuber into four sections so that the four seed pieces will remain attached. The tuber is easily broken apart for unit planting. With this method it becomes easier to identify tubers affected with virus diseases. All plants from the same tuber should be removed if any one of them shows symptoms of a virus disease. Tuber-unit planters are now available on the market.

The additional expense of producing certified seed is generally justified because seed buyers and consumers prefer seed that is free from disease, true to type, and of high yielding ability.

DISEASES

The potato is subject to many diseases, some of which cause considerable loss. Not all these diseases are likely to occur in the same field or district at the same time, since the weather conditions favoring some are unfavorable to others. The control or prevention of these diseases is one of the most important considerations in growing potatoes and in producing high yield.

Brief descriptions of the most common and serious diseases of potatoes in the South and their control are given herein. Detailed information on them can be found in Farmers' Bulletin 1881, Potato Diseases and Their Control.

DISEASES CAUSED BY VIRUSES

The virus diseases, such as mild mosaic, rugose mosaic, leaf roll, and spindle tuber, are very important on potatoes in the South. Tubers from infected plants carry the virus and when planted produce diseased plants. Such affected plants should be removed from fields producing seed stock, but it is not necessary to remove them from plantings for table use. The spread of virus diseases is influenced by the abundance of certain species of insects, especially aphids. (See p. 36.) The aphids, of which the green peach aphid (*Myzus persicae* (Sulz.)) is most important, are the chief vectors or carriers of potato viruses.

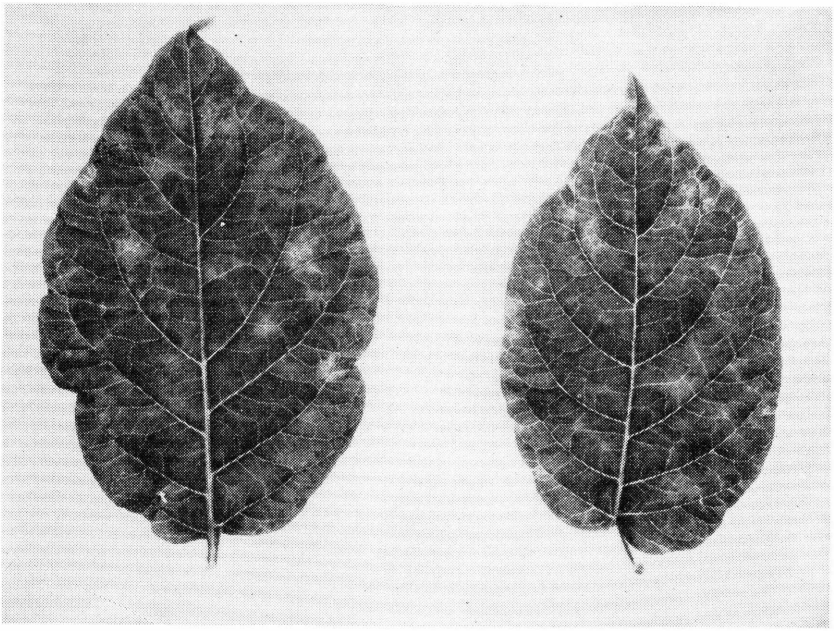

FIGURE 14.—Leaflets of a Green Mountain potato plant affected with mild mosaic.

Mild Mosaic

Mild mosaic is characterized by a definite mottling in which yellowish or light-colored areas alternate with similar areas of normal green in the leaf (fig. 14). A slight crinkling is usually present; under conditions favorable for the disease the margins of the leaflets may be wavy or ruffled. Diseased plants tend to be slightly erect at first and are stunted; later they droop and die prematurely. It is difficult to detect mild mosaic in affected plants during warm weather, since the symptoms may not be apparent under such conditions. Subsequent cooler weather results in the appearance of the symptoms. Such masking of the symptoms makes it important to plant in tuber units all seed that is being produced for new foundation stock. It is much easier to determine the presence of the disease when the several plants coming from different sets of a single tuber are growing side by side in the row.

The loss in yield from mild mosaic varies according to the severity of the disease, the character of the growing season, and the resistance of the variety. Usually affected plants will not produce, on an average, more than three-fourths of the normal yield. The tubers tend to be fewer in number and smaller than those in healthy hills. The use of certified seed will materially reduce loss from this disease. Katahdin, Chippewa, Earlaine, Sebago, and Houma varieties are all resistant to this disease.

Rugose Mosaic

Rugose mosaic is more destructive than mild mosaic and is distinct from it. Plants from diseased tubers are dwarfed and the leaves are mottled, the mottled areas being smaller and more numerous than in mild mosaic. Such mottling may be readily masked at high tempera-

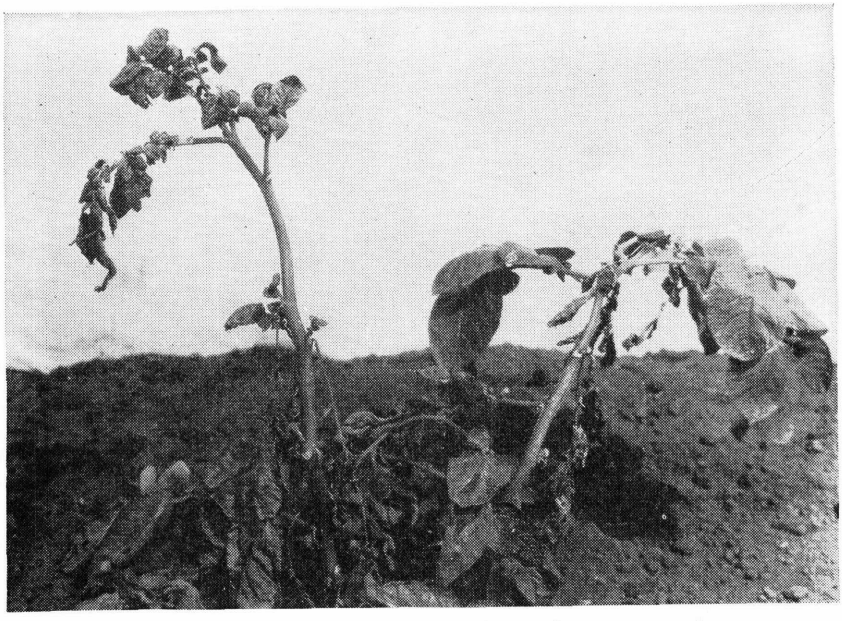

FIGURE 15.—Current-season symptoms of rugose mosaic.

tures, but a distinct crinkling is always present. The under sides of lower leaves generally show more or less blackening and death of veins.

Symptoms, such as blackened veins and areas of the leaves in the upper portion of the plant (fig. 15), may appear in the current season from direct infection of the growing plant. Tubers from plants with current-season infection will produce plants with rugose mosaic the following season.

No varieties resistant to rugose mosaic are known, but Katahdin contracts the disease less rapidly than do other varieties. The use of dependable certified seed is recommended.

Leaf Roll

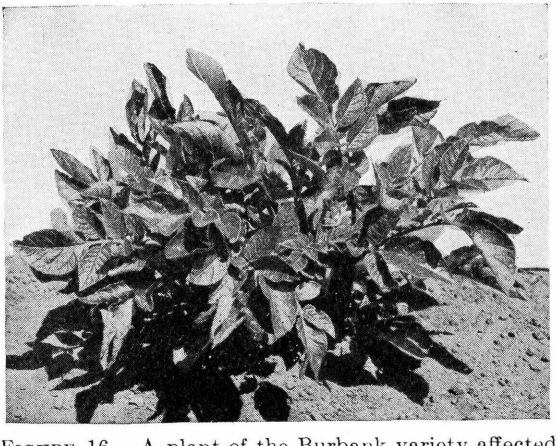

FIGURE 16.—A plant of the Burbank variety affected with leaf roll.

The first symptoms of leaf roll usually appear about 1 month after the plants emerge from the ground and may vary somewhat in different varieties. The leaflets of the lowermost leaves become leathery and roll upward at the edge. Usually as the season advances a similar rolling appears on progressively higher leaves until most of the leaves of the plant

are involved. These rolled leaves become yellow green instead of dark green, and the plants are considerably dwarfed (fig. 16). Affected leaves are brittle to the touch and rattle if brushed with the hand. Hastening of plant maturity does not occur except in the most severe cases. A large proportion of the tubers are small or medium-sized, and the yield of affected plants may be reduced to one-third or one-half of the normal.

Only certified seed stock known to have come from plantings that were free from leaf roll should be used for planting.

Spindle Tuber

In most varieties, spindle tuber is well characterized by a pronounced elongation of the tubers. These are small and may become pointed at one or both ends (fig. 17). Affected colored tubers are paler in color. In some affected round varieties, such as Triumph and Irish Cobbler, the tubers became somewhat elongated and have rounded ends.

The plants are more erect and somewhat spindling in growth, and there are narrowness of shoots, dwarfing, and a decidedly darker green color of the foliage. The erectness and dwarfing make the diseased plants conspicuous when the symptoms are prominently developed. Symptoms of spindle tuber are most prominent at high temperatures and are considerably masked at low temperatures.

The disease may cause a marked reduction in yield, and the tubers are often so poorly shaped as to be of low commercial grade. Certain insects, such as grasshoppers, flea beetles (see p. 34), the tarnished plant bug, and the Colorado potato beetle (see p. 34), spread the disease. Cutting knives and picker planters also spread it. It can be controlled by the use of good certified seed.

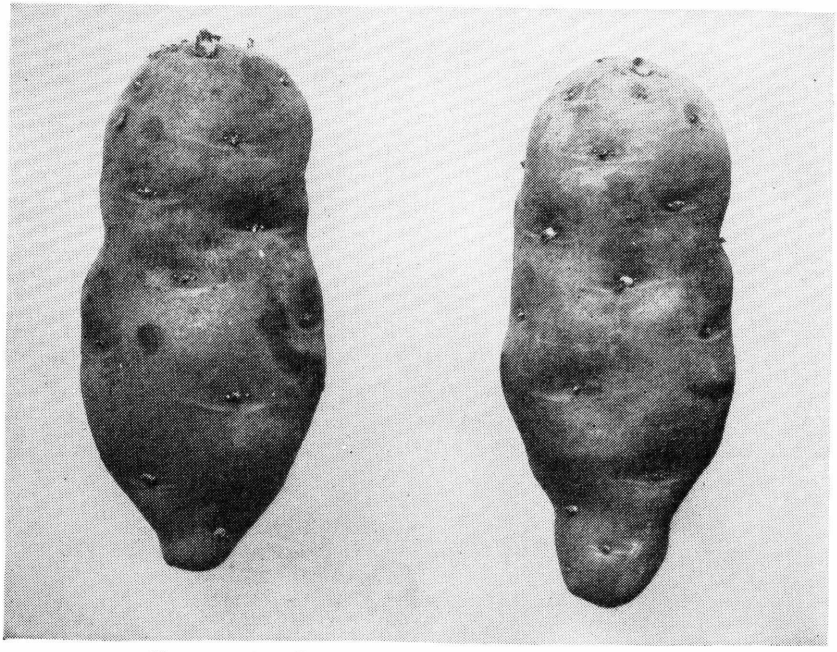

FIGURE 17.—Potatoes affected with spindle tuber.

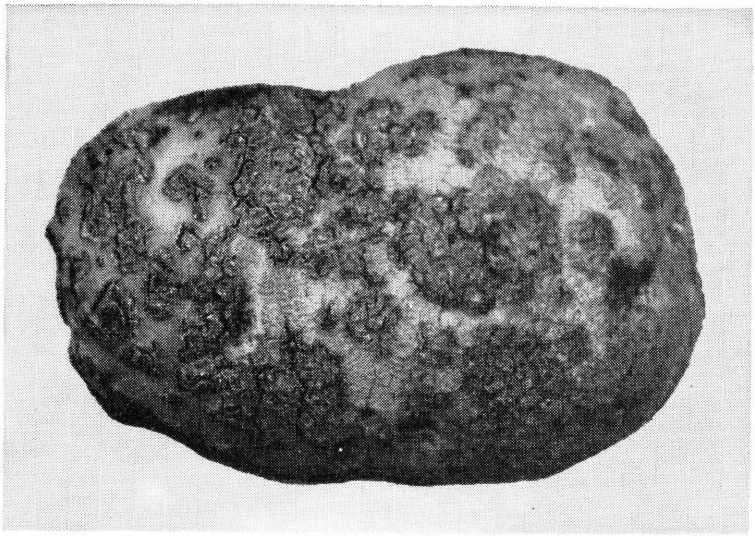

FIGURE 18.—Common scab of potatoes.

DISEASES CAUSED BY FUNGI AND BACTERIA

Common Scab

Common scab is caused by a soil-inhabiting fungus (*Actinomyces scabies* (Thax.) Güssow), and is both seed- and soil-borne. The appearance of the disease is well known, being chiefly characterized by round, corky pits on the skin of the potato (fig. 18), varying from mere specks to deep irregular pits or even raised spots.

The development of common scab is favored by an alkaline soil reaction, but it occurs in slightly acid soils. Increasing soil acidity will check the development of the fungus. The addition of lime or barnyard manure to any soils, except very acid ones, tends to increase its activity. The fungus develops best when the soil moisture is slightly below the optimum for development of the potato plant. In loose, well-aerated soils, it may develop readily even under very wet conditions.

The control of this disease resolves itself into several lines of attack. Since the organism causing the disease prefers alkaline conditions for development, any practice that would make the soil more acid would help in control. The application of sulfur at the rate of 300 to 600 pounds an acre on lighter types of soils generally reduces somewhat the severity of the attack.

Common scab is of very little importance on the seed, since it can be practically eliminated on moderately infected tubers by treatment with hot formaldehyde or with acidulated mercuric chloride. (See pp. 7 and 9.)

Rhizoctonia Canker (Black Scurf)

Rhizoctonia canker, or black scurf, is caused by a fungus *Rhizoctonia solani* Kühn (=*Corticium solani* (Prill. and Del.) Bourd. and Galz.), which under conditions favorable for its development may be the cause of considerable reduction in stand and yield.

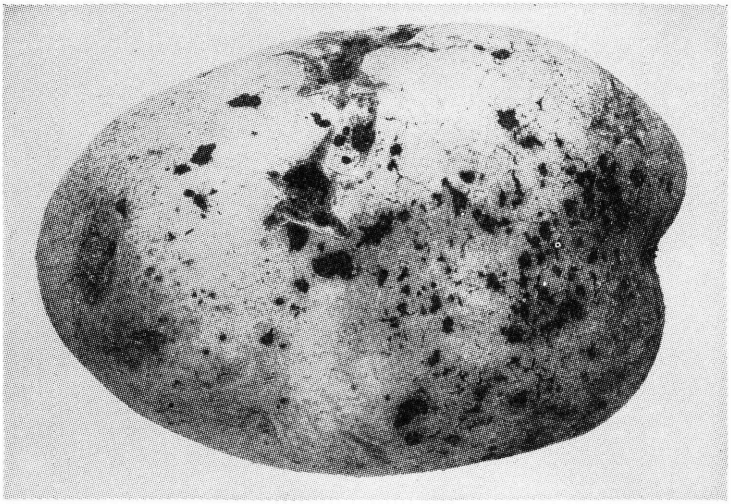

FIGURE 19.—Rhizoctonia canker, or black scurf; a tuber partly covered with hard black fungus masses.

The most common symptom of the disease is the development on the skin of the mature tubers of irregular small black masses (fig. 19) that look like dirt, but are hard crusts and do not wash off. This form of the disease does little harm in itself, but detracts somewhat from the appearance of the tubers. In the southernmost sections these masses are seldom, if ever, produced on the tubers, but the wefts of coarse brown fungus threads may be apparent on stalks, stolons, or tubers.

When such infested tubers are planted, the fungus starts growing and may attack the young sprouts. This phase of the disease results in missing hills or weak plants. In this stage, the disease is recognized by the brown decayed areas on the white underground stems (fig. 20) that often entirely girdle the stems. Plants attacked in this manner may turn yellowish, the leaves may become considerably rolled, and small greenish tubers may appear on the stems above ground.

The fungus causing this disease thrives best at relatively low temperatures and under moist conditions. Thus, it is most likely to attack potatoes planted in the cooler part of the year.

Rhizoctonia canker can be controlled by treatment of seed stock with either hot formaldehyde or acidulated mercuric chloride. (See p. 7.) Planting on a ridge tends to reduce the seriousness of this disease, since the soil warms up more rapidly than that on flat land, thus making conditions unfavorable for the fungus.

Ring Rot

Ring rot, or bacterial ring rot, caused by *Phytomonas sepedonica* (Spieckermann) Magrou, has only recently appeared in all the commercial potato-growing areas of the South. It is a very destructive seed-borne disease, which caused considerable damage in Florida in 1937, 1938, and 1939 and in a number of the Northern and Western States in recent years.

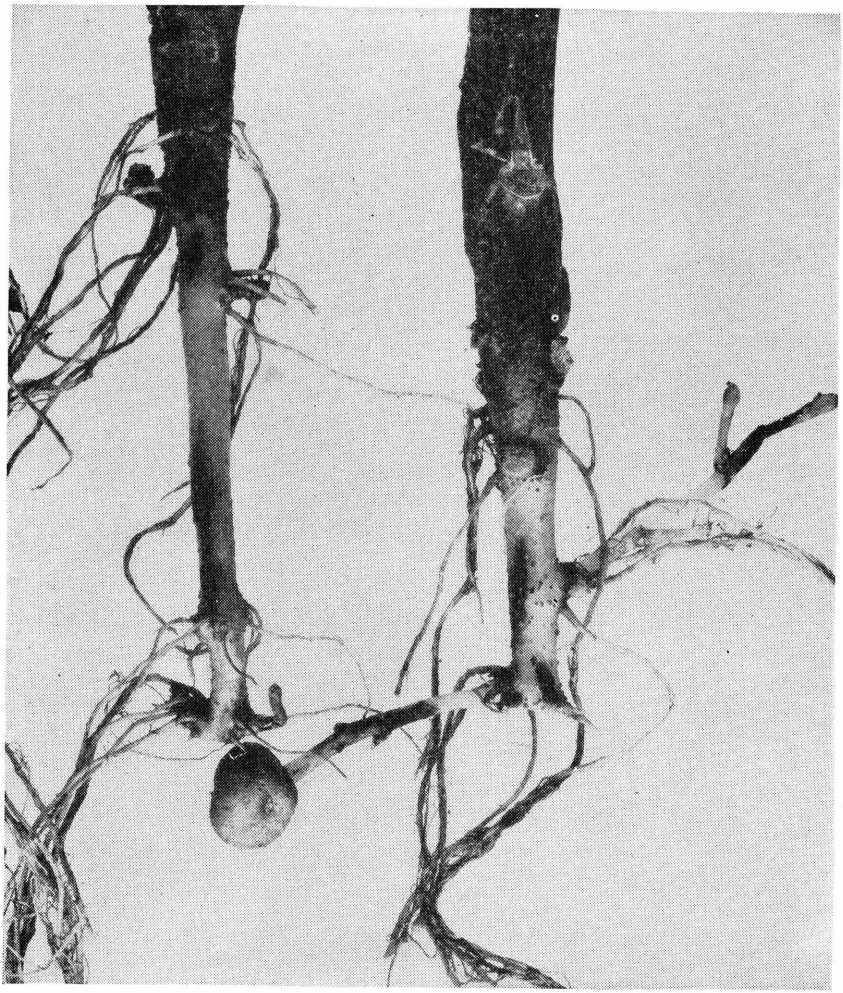

FIGURE 20.—Stalk and stolon lesions caused by the black scurf fungus, *Rhizoctonia solani*.

This disease does not usually become evident until late in the growing season; however, plants may become infected and not show symptoms in the leaves. The first symptom of the disease in the foliage is a wilting of the tips of leaves and branches (fig. 21). Later the leaves become slightly rolled and mottled and fade to a pale-green followed by a pale-yellow color. Dead areas develop on the leaves, and the affected plants gradually die.

When dug, diseased hills usually contain tubers ranging from those that are apparently sound to those that are completely decayed. Decay begins in a region immediately below the skin, thus causing a ring rot appearance (fig. 22). The decayed tissues are soft and crumbly and may be gray, cream, yellow, or reddish brown.

All evidence indicates that the organism causing the disease does not live in the soil from one season to the next where the disease has

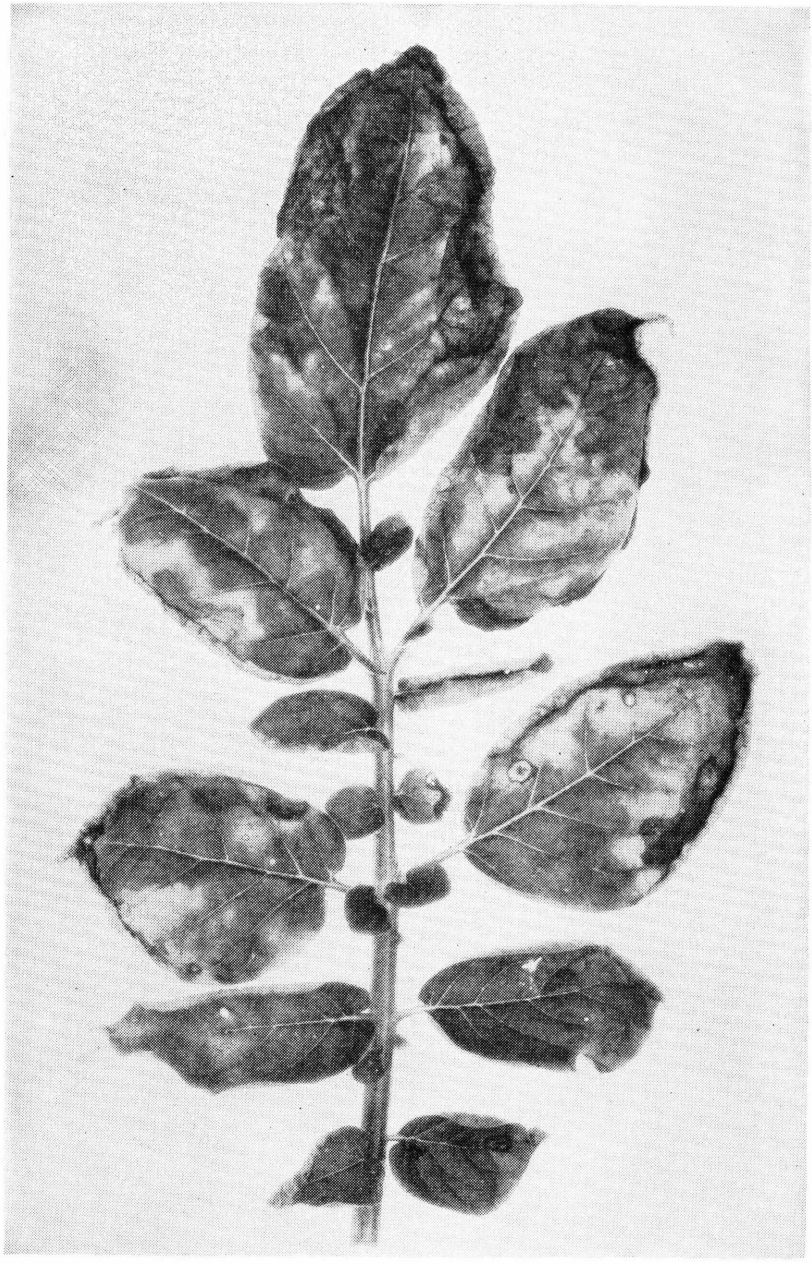

FIGURE 21.—A potato plant affected with ring rot, showing wilted branches and leaves. (By courtesy of the Florida Agricultural Experiment Station.)

FIGURE 22.—A potato tuber affected with ring rot. (By courtesy of the Florida Agricultural Experiment Station.)

been found in the Southern States. Since tubers may be infected without showing any symptoms, it is apparent that the disease cannot be entirely controlled by examination of seed tubers at the time of cutting. It is possible, however, to discard the severely affected tubers at this time. The organism is spread by the cutting knife and the equipment used in planting, digging, and transporting the crop. The planting of whole tubers avoids spread of infection in cutting and gives some control.

It should be emphasized that one should not buy infected seed, which may be cheaper than healthy seed, and attempt to control the disease by culling out affected tubers. Since ring rot occurs in every northern seed-producing area, only dependable certified seed should be used, to avoid possible loss from ring rot.

FIGURE 23.—Potato affected with brown rot, or bacterial wilt.

Brown Rot (Bacterial Wilt)

Brown rot, or bacterial wilt, caused by *Phytomonas solanacearum* (E. F. Smith) Bergey et al., sometimes referred to as southern bacterial wilt, has been most destructive on potatoes in the Hastings, Fla., locality. In some years the loss due to this disease alone has been greater than that caused by all other potato diseases.

In the early stages the disease is characterized by a slight wilting of the leaves at the ends of the branches during the hottest portion of the day. Affected plants recover during the night, but the wilting becomes more severe each day until the plant dies. Usually the entire top of the plant wilts and dies, but occasionally only a few branches may be affected and the others may remain healthy. Brownish rings are formed in the stems, roots, and stolons. This brown color eventually appears on the outer surface of these parts and is found on the stem for 1 or 2 inches above the ground line. When affected plant parts are cut, a white slimy ooze soon forms on the cut surface.

External symptoms on the tubers may or may not be present, depending on the stage of development of the disease when the tubers are dug. The first sign of the disease in the tuber is a more or less complete brown circle seen in cross section slightly underneath the skin (fig. 23), particularly around the eyes and at the stem end. A slimy ooze comes from the eyes and stem end of severely affected tubers. The disease progresses in the tuber until finally the skin is broken and cracking develops.

The Florida Agricultural Experiment Station finds that in fields where tuber infection is less than 5 percent in susceptible varieties, such as Spaulding Rose, it is preferable to avoid brown rot by growing one of the more resistant varieties, such as Katahdin. Where the tuber infection exceeds 5 percent in susceptible varieties, treating the soil with sulfur and limestone has given good control. An application of 800 pounds of sulfur to the acre in June, followed by 3,000 pounds of dolomitic limestone an acre in November of the same year, has given control of brown rot on a sandy soil at Hastings, Fla.

Powdered sulfur is injurious to eyes and respiratory passages. A suitable respirator, having a full facepiece, should be worn by persons applying sulfur.

Brown rot is found only in potatoes grown in soil infested with the organism. It does not occur in the northern seed-producing areas; hence, it would not be found in seed potatoes coming from there.

Comparison of Brown Rot and Ring Rot

Brown rot and ring rot are two distinct diseases caused by different bacteria. Both of them are seed-borne, but brown rot occurs only in the South, whereas ring rot occurs in every potato-growing district of the United States. In Florida, and perhaps in other areas of the far South, the organism causing ring rot does not live from one season to the next in the soil. On the other hand, the organism causing brown rot does persist in the soil.

Both diseases appear late in the crop season and cause wilting and death of the plants. The leaves of plants affected with brown rot become pale green and then brown as they die. Ring rot causes a leaf mottling, and the color fades to pale green, then pale yellow, with

later browning at the margins as the leaves roll upward and finally die.

Brown rot produces a slimy, brown to black discoloration of diseased areas in the tuber, whereas ring rot produces a soft and crumbly condition and a gray, cream, yellow, or reddish-brown discoloration.

Late Blight

Late blight, caused by *Phytophthora infestans* (Mont.) DBy., is more prevalent in the States along the Atlantic coast than in other parts of the South. It develops under cool conditions, and on the main crop it is particularly destructive in the northern regions and at high altitudes in the South. It sometimes severely attacks the early crop in coastal areas.

The blight is usually seen first on the margins of the lower leaves and works inward until entire leaves may be affected and killed. Irregular water-soaked spots develop at the margins of the leaves. A white fungus growth may often be observed on the under surface

FIGURE 24.—Late blight: At right, two rows of the variety Green Mountain killed by late blight; at left, plants in the two rows are resistant to late blight and are still green.

of affected areas. Under conditions of high moisture with warm day temperatures and cool nights the spots enlarge rapidly and the infection spreads to other leaves. All the plants in a field may be killed in a few days. A noticeable odor is given off from the dead foliage in fields that are severely attacked.

The organism may also attack the tubers and produce in them slightly sunken brownish or purplish spots that enlarge until the entire tuber is affected. When such tubers are cut, the interior shows granular brick-red blotches, a distinctive characteristic of late blight. Infected tubers may rot in the field or in storage.

An 8–8–100 bordeaux-mixture spray (see p. 32) will control late blight and should be applied as soon as symptoms of the disease appear. The spraying should be repeated at weekly intervals so as to keep the foliage well covered.

Bordeaux mixture will cause gastric disturbances if taken internally and all unused solutions should be safely disposed of at once. As the mixture is somewhat irritating to the eyes and skin, spray operators should wear goggles and oiled leather gloves. All protective devices and clothing should be cleansed promptly.

The use of resistant varieties (fig. 24) is the best means of controlling late blight. The Sebago variety, developed by the United States Department of Agriculture, is highly resistant to this disease in foliage and tubers.

Early Blight

Early blight, caused by *Alternaria solani* (Ell. and Mart.) Jones and Grout, is a very common disease of potatoes and in some years causes noticeable damage. It usually becomes serious several weeks before harvest.

Small, scattered, dark, circular spots are first produced on the lower leaves (fig. 25), which often become yellow. These spots enlarge, and the affected tissue dies. The enlarged spots develop a series of concentric rings and produce a target-board effect.

Spraying with 8–8–100 bordeaux mixture (see p. 32), as recommended for late blight, gives control of early blight. **(See caution for bordeaux mixture given above.)**

Sclerotium Rot (Southern Blight)

Sclerotium rot, or southern blight, caused by *Sclerotium rolfsii* Sacc., is a disease of potatoes and many other vegetable crops of the southern part of the United States. The organism causing the disease is a soil-inhabiting fungus, which under favorable conditions of moisture and temperature attacks a wide range of hosts.

Plants are attacked most frequently at the surface of the ground. During the heat of the day the young leaves wilt, but they recover at night. As wilting progresses the foliage turns yellow, and the leaves fail to recover. After this the leaves die, the stems lose their color, and the entire plant dries out and dies.

At the collar of affected stems sunken discolored areas are produced, usually just below the surface of the ground. These areas later become water-soaked and finally become covered with a white

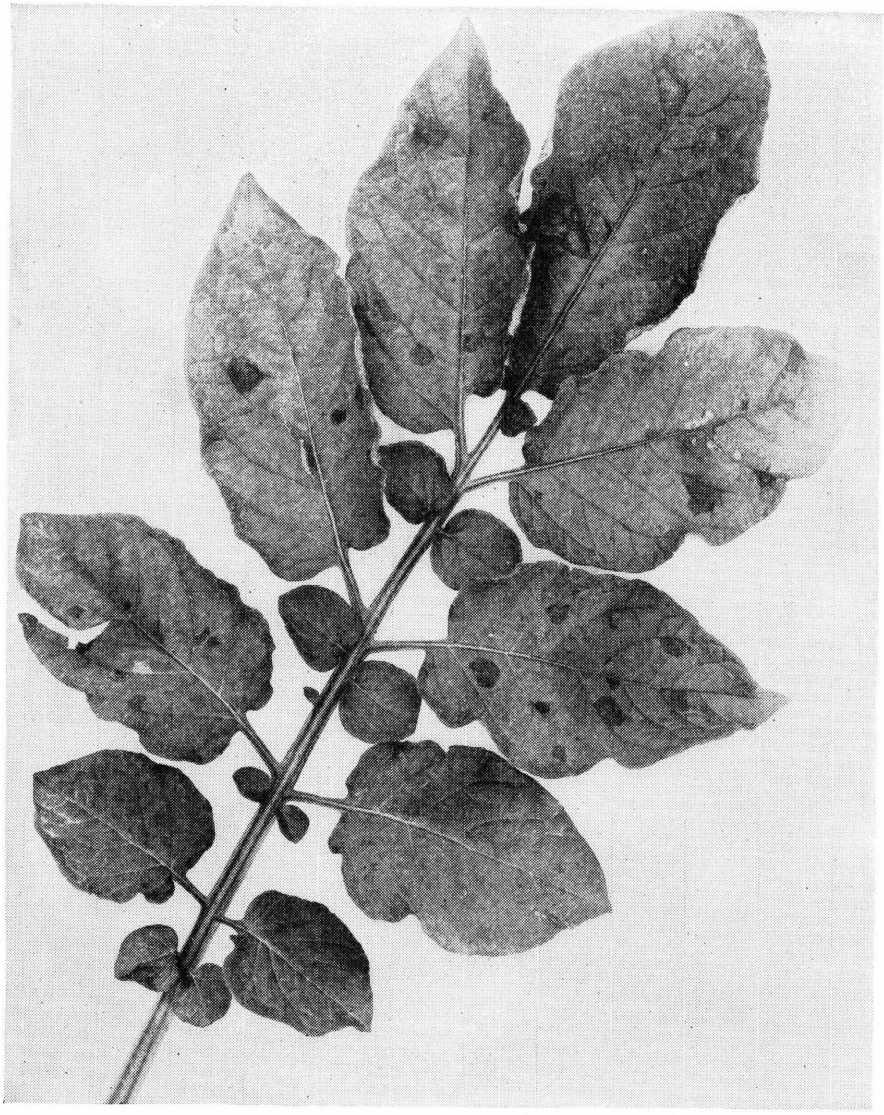

FIGURE 25.—Potato leaf affected with early blight.

mat of fungus. The fungus growth on the underground stem is so characteristic that this disease is not readily confused with any other. It is a fine, silky, white growth (fig. 26) developing in a more or less radial fashion and forming fans. These fans may be found on the soil as well as on plant parts and even on crates or bags. In these white mats are produced small fruiting bodies that are white at first but later become dark and resemble radish or mustard seed in color, shape, and size.

Decay of tubers in the soil sometimes occurs, particularly during extended wet periods. In the early stages of development the rot is

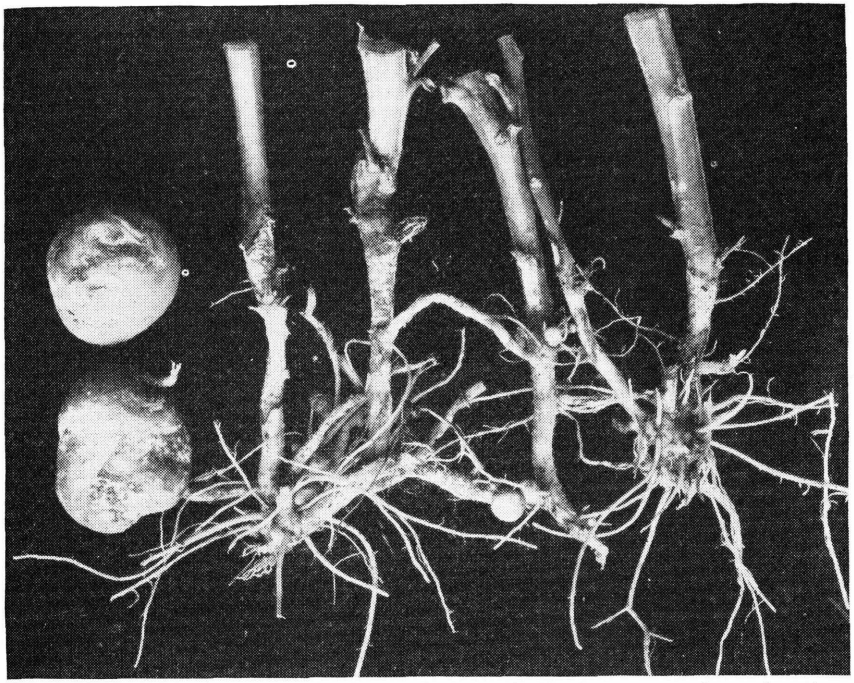

FIGURE 26.—Potato stalks and tubers infected with the fungus causing sclerotium rot. (By courtesy of the Department of Botany, Bacteriology, and Plant Pathology, Louisiana Agricultural Experiment Station.)

white and almost odorless; in later stages it becomes yellow. In mild cases only slightly sunken spots are produced, but often the decay develops rapidly and involves the entire tuber, producing a slimy condition.

Since the fungus is soil-borne and attacks a wide range of crops, control is difficult. The disease is usually of only minor importance, and the fungus spreads very slowly in the soil. However, as serious losses of potatoes frequently occur in transit, avoidance of harvesting and packing operations during wet weather and thorough drying of tubers before packing are recommended as precautionary measures.

Fusarium Wilt

Fusarium wilt may be caused by *Fusarium oxysporum* Schl. or *F. eumartii* Carpenter in the South. Although this disease never becomes epidemic, it is distributed generally throughout the potato-growing sections of the South. The outstanding symptom is a distinct wilting of affected plants. Wilting is accompanied by yellowing of the lower leaves on one or more stalks in a hill. The lower parts of affected stems are always discolored in the interior. Such tissues show a brown discoloration that extends upward in the stem and downward through the roots and stolons into the tubers. Affected plants die prematurely (fig. 27).

The same type of discolorations often occurs in water vessels near the stem end of the tubers (fig. 28). All tubers showing such discoloration are not infected with the fusarium wilt organisms, as there are other agencies that cause this type of symptom.

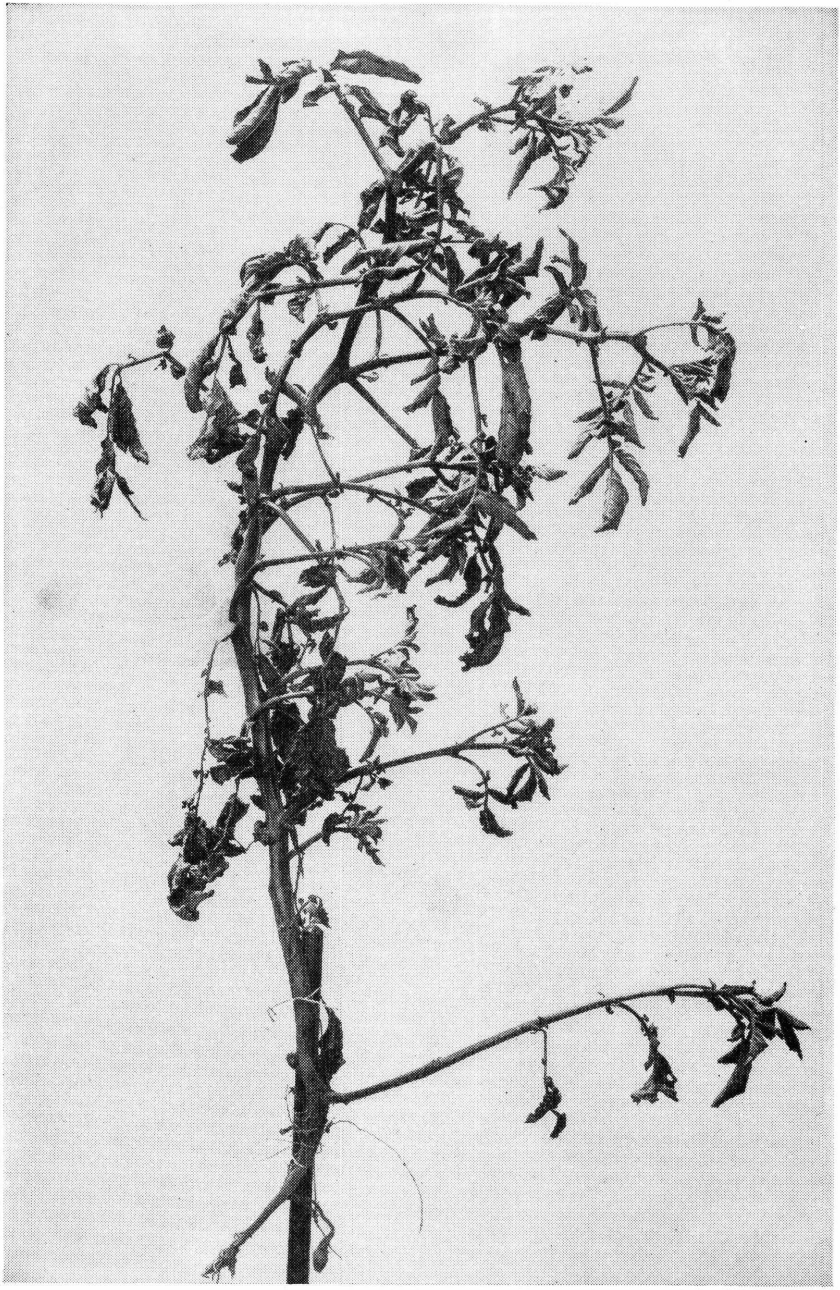

FIGURE 27.—Potato plant affected with fusarium wilt.

Since fusarium wilt is carried over in the tuber and in the soil, control measures are only partially effective. All tubers showing stem-end discoloration should be discarded when the seed is cut. It is recommended that all wilted plants be eradicated where certified seed is being produced.

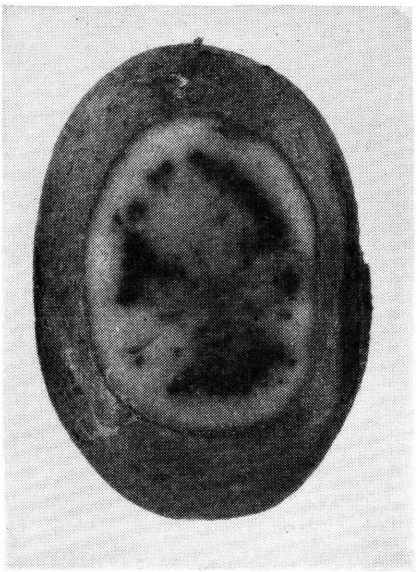

FIGURE 28.—Fusarium wilt in stem end of tuber.

GENERAL CONTROL MEASURES

The control and prevention of diseases of potatoes may be considered from the standpoint of crop rotation, certified seed, seed disinfection, spraying and dusting, and resistant varieties.

CROP ROTATION

Since some of the most destructive organisms causing diseases of potatoes live over in the soil, potatoes should be grown in rotation with other crops. Crop rotation may affect the quality as well as the yield of potatoes. Generally, common scab and rhizoctonia canker, or black scurf, are more prevalent in short rotations than in long ones.

A great diversity of crop rotations are possible; the rotations vary from one area to another. A good rotation maintains the fertility of the soil and thus makes possible higher yields. The use of green-manure crops, such as soybeans and cowpeas, gives satisfactory results.

As a rule, potato production in the South could be materially improved by adopting a system of crop rotation that would insure the addition to the soil of a larger amount of organic matter, thus reducing erosion and leaching and permitting a broader diversification of crops.

CERTIFIED SEED

The nature of virus diseases of potatoes and of some of the other diseases is such that control measures have to be based on disease avoidance rather than on later control. This can best be accomplished by the use of dependable certified seed.

The value of certified seed has been well demonstrated in all the potato-producing areas of the South. It has been found, almost without exception, that higher yields are obtainable with certified than with noncertified seed. The principal advantage of certified seed, as compared with noncertified seed, is the assurance that it is practically free from ring rot and such virus diseases as mosaics, leaf roll, and spindle tuber.

SEED DISINFECTION

The four standard methods of seed-potato disinfection have been discussed on pages 7 to 10.

FIGURE 29.—A large power-spraying machine. (By courtesy of the manufacturer.)

SPRAYING AND DUSTING

The potato crop is sprayed (fig. 29) or dusted for two reasons: (1) As a protection against insects (see p. 33); and (2) for the control of fungus diseases, which frequently destroy the plants. The two fungus diseases of the potato plant controllable by spraying or dusting are early blight and late blight. Applications of fungicides and insecticides are most valuable when other good practices are followed.

Bordeaux Mixture [4]

Bordeaux mixture is very effective in controlling late blight and early blight. Home-made bordeaux mixture consists of copper sulfate, high-grade hydrated lime, and water in the following proportions: Copper sulfate (bluestone, or blue vitriol), 8 pounds; hydrated lime, 8 pounds; water, 100 gallons. This is known as an 8–8–100 mixture. **In using bordeaux mixture and copper sulfate, the operator should observe the precautions given on page 27.**

A stock solution of copper sulfate may be made in a barrel by dissolving 50 pounds of copper sulfate in 50 gallons of water. The use of finely powdered copper sulfate is recommended, as it dissolves more readily than the crystals. Solution may be hastened by suspending the copper sulfate in a clean loosely woven sack near the top of the barrel. Similarly, a stock mixture of lime is made by mixing 50 pounds of fresh hydrated lime in 50 gallons of water. Lump lime (quicklime) may be used after slaking. Partly air-slaked lime should not be used.

To prepare 50 gallons of an 8–8–100 mixture, pour 4 gallons of the copper sulfate solution into the sprayer and then add 42 gallons of water; 4 gallons of the well-stirred stock mixture of lime is then added to the dilute copper sulfate mixture. As the lime is being

[4] No spray that is a satisfactory substitute for bordeaux mixture in controlling early and late blights is known. In case a prospective grower finds that he cannot obtain copper compounds during the present emergency, he must consider the risk and problems involved in trying to grow potatoes without them.

poured in, it should be run through a strainer in order to remove the large particles of lime. It is very important to keep the copper sulfate solution agitated while the milk of lime is being added. Calcium arsenate or lead arsenate may be added to the bordeaux mixture if chewing insects are to be controlled. **Both these substances are poisonous and increase the dangers of mixing and using the spray.** (See p. 34.) **In spraying potatoes in gardens, care should be taken not to get spray containing arsenates on edible portions of vegetables growing near the potatoes.**

Thorough and careful spraying with bordeaux mixture has a deterrent effect on leafhoppers and reduces to a considerable degree the hopperburn injury caused by them. The addition of 4 pounds of calcium arsenate to 100 gallons of bordeaux mixture for the first one or two applications of the regular spray schedule will control the Colorado potato beetle.

Copper-Lime Dust

Many growers prefer a dust to a spray. Dust is effective when properly applied and should be used when the potato vines are wet and when the air is still. Copper-lime dust has been found to be effective in controlling the diseases and insects that are controllable by bordeaux mixture. A mixture of 20 percent of powdered monohydrated copper sulfate and 80 percent of hydrated lime is recommended as a substitute for bordeaux mixture. In the presence of moisture on the foliage the copper-lime dust produces a fungicidal film comparable to bordeaux mixture. When a poison is needed for insects, 20 pounds of calcium arsenate is substituted for an equal quantity of hydrated lime in the mixture.

Copper-lime dust is injurious to the eyes and respiratory passages. A suitable respirator, having a full facepiece, should be worn by persons applying it. The addition of calcium arsenate increases the dangers of mixing and using this dust.

RESISTANT VARIETIES

The national potato-breeding program that is being carried on by the United States Department of Agriculture and a number of State experiment stations has done much to reduce losses from diseases by the production of resistant varieties. Some varieties resistant to certain diseases have already been released and are grown commercially; others will appear as the work progresses. Information as to adaptation of these new varieties can be obtained from the State agricultural experiment station. The Katahdin, Sebago, Chippewa, Houma, and Earlaine varieties are highly resistant to mild mosaic. Katahdin and Chippewa are also high-yielding potatoes, the former being very widely adapted to the different early- and late-potato-growing sections of the South. Sebago, which is resistant to late blight as well as to mild mosaic, produces good yields. Sequoia is highly resistant to leafhoppers. Houma is of good quality and is more heat-resistant than most varieties.

INSECTS AND THEIR CONTROL[5]

The common insect enemies of potatoes in the Southern States are the Colorado potato beetle, the potato flea beetle, the potato tuber worm, potato aphids, the seed-corn maggot, the potato leafhopper, and wireworms and other soil-infesting insects.

[5] Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine.

COLORADO POTATO BEETLE

The Colorado potato beetle (*Leptinotarsa decemlineata* (Say)) is one of the most widespread and destructive insect pests of potatoes in this country. The insect first appears in the spring in the form of the adult, or hard-shell beetle, which is about two-fifths of an inch long. It is stout and roundish and of a light yellowish color, with 10 black stripes down its back. The female beetles lay their orange-red eggs in batches of 5 to 70 on the under sides of the potato leaves. These eggs hatch in from 4 to 9 days into small larvae, or "slugs." These slugs have soft bodies, which range in color from lemon to reddish brown and are marked with two rows of black spots on each side. The head and legs are black. The slugs feed greedily and grow rapidly for a period of approximately 2 weeks, during which they devour large quantities of potato foliage. At the end of this period they reach full growth and are about three-fifths of an inch long. At this stage they drop from the plant and enter the soil, where they change to the inactive, or pupal, stage. They remain in this stage for a short time, the length depending upon the time of year and the locality. At the expiration of this period the adult, or beetle, may emerge from the soil and fly to a potato field to start a new generation of the pest. There may be one to two generations of this insect each year, depending upon climatic conditions.

The Colorado potato beetle can be controlled with insecticides containing arsenicals or rotenone. For sprays, use 1 pound of paris green and 4 pounds of hydrated lime, or 4 pounds of calcium arsenate, or 4 pounds of lead arsenate, or 4 pounds of derris or cube root containing from 4 to 5 percent of rotenone, to each 100 gallons of water. If a bordeaux mixture spray is to be applied for the control of diseases, add the arsenicals in the quantities mentioned, to each 100 gallons of the bordeaux mixture. (See p. 32.) For dusts, use them at the rate of 1 pound of paris green or lead arsenate to 12 pounds of hydrated lime or equal parts of calcium arsenate and hydrated lime, or use a dust mixture containing 0.75 percent of rotenone. Although the insecticides containing rotenone are effective in controlling the Colorado potato beetle, they are more expensive than the arsenicals.

In handling, mixing, and applying poisonous insecticides, especial care should be taken not to inhale excessive quantities at any time. Well-designed respirators affording protection to the entire face are available and should be used when such danger exists. After work with insecticides the hands or any exposed parts of the body should be washed thoroughly.

POTATO FLEA BEETLE

In some sections of the South the potato flea beetle (*Epitrix cucumeris* (Harr.)) not only causes reductions in the yield of potatoes because of the feeding of the beetles on the foliage, but the attacks of the larvae on the potato tubers have resulted in producing potatoes of inferior quality. The adult of the potato flea beetle is about one-sixteenth of an inch long, black in general appearance, with yellow legs. When disturbed, it jumps quickly and may readily disappear from sight. It feeds on both surfaces of the leaves, producing numerous small holes. Severely injured leaves may dry up and fall from the plant. The immature form of the flea beetle is a slender, white, wormlike larva, approximately one-fifth of an inch long. It feeds on the roots and tubers. On the tubers its feeding results in tiny tunnels

near the surface of the tubers and pimplelike scars on the surface.

According to results reported by the Virginia Truck Experiment Station, the potato flea beetle may be controlled by spraying at 7- to 10-day intervals with 4 pounds of calcium arsenate to 100 gallons of bordeaux mixture. (See p. 32.) If spray equipment is not available, dust with a calcium-arsenate-monohydrated-copper-sulfate-hydrated-lime mixture (25–20–55). Dusting is not so effective, however, as spraying for the control of this insect.

POTATO TUBER WORM

The potato tuber worm (*Gnorimoschema operculella* (Zell.)) is the immature stage of a small gray moth that deposits its eggs on the foliage of potatoes and related plants. In potato storages the moth lays eggs near the eyes of the tubers or in other depressions. The eggs are also found on sacks in storages and on debris between the tubers and soon hatch into small white tuber worms that develop a pinkish cast along the back as they mature. When full-grown, the tuber worm is only about two-fifths of an inch long. In the field the young tuber worms are leaf or stem miners. When the infested foliage dries, the tuber worms leave the mines in the foliage and find their way to the tubers through cracks in the soil. The tuber worms tunnel throughout the tubers and render them unmarketable (fig. 30).

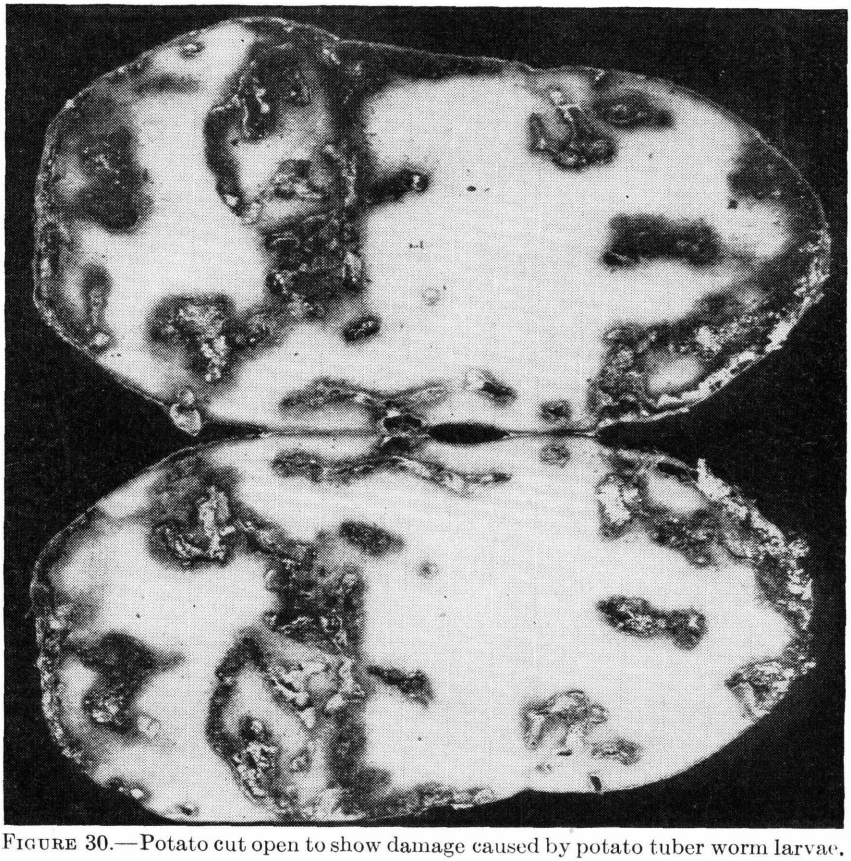

FIGURE 30.—Potato cut open to show damage caused by potato tuber worm larvae.

The tuber worm is best controlled by cultural practices, careful clean-up measures, and fumigation of storages. In infested fields the tubers should be kept well covered with soil until harvested and should be harvested as soon as possible after they reach maturity and before the vines die. The tubers should be picked up and removed from the field as soon as the fields are plowed, in order to reduce the possibilities of infestation. During the harvesting operation, vines should never be placed over the containers of tubers, since potato tuber worm larvae may leave the vines when they wither and crawl to and infest the tubers. All culls and infested tubers should be destroyed or fed to stock immediately after harvest. All volunteer potato plants should be destroyed. In tidewater Virginia, where there is a large area of concentrated potato acreage, the elimination of the fall crop is advisable in seasons following an outbreak of this insect. Uninfested potatoes should not be stored in or near places that have contained infested potatoes unless the storage space has been cleaned carefully and fumigated with methyl bromide or carbon disulfide. Tuber worms within the tubers may be killed by fumigating for 3 hours with methyl bromide at the rate of 2.4 pounds per 1,000 cubic feet of space, including that occupied by the tubers. For specific information on the proper use of this fumigant consult your State entomologist.

Methyl bromide is a poisonous gas and, being odorless, should be handled with extreme caution. Gas masks should be worn while working with methyl bromide, and the work should be supervised either by a commercial fumigator or by a person thoroughly familiar with fumigation practices.

POTATO APHIDS

Several species of soft-bodied plant lice, or aphids, attack potato foliage. The potato aphid (*Macrosiphum (Illinoia) solanifolii* (Ashm.)) varies in color from green to pink and is often called the pink and green potato aphid. The green peach aphid (*Myzus persicae* (Sulz)), which is also commonly found on potatoes, is green in color. When abundant, these aphids reduce the yield of tubers by sucking the juices from the foliage. Aphid infestations are difficult to control, but if control operations are begun at the early stages of the infestation by spraying with a mixture containing 1½ pints of nicotine sulfate to 100 gallons of bordeaux mixture (see p. 32) good results can be obtained. Another spray for aphids on potatoes can be prepared by adding 3 pounds of derris or cube root powder and 2 quarts of soybean oil to 100 gallons of bordeaux mixture. Where bordeaux mixture is not needed for the control of diseases, a nicotine soap solution consisting of 1½ pints of nicotine sulfate, 4 to 5 pounds of soap, and 100 gallons of water may be used. Dust mixtures containing three-quarters of 1 percent of rotenone are also effective against the aphids.

SEED-CORN MAGGOT

The seed-corn maggot (*Hylemya cilicrura* (Rond.)) is the immature, or maggot, stage of a small fly that lays its eggs on soil and decaying vegetable matter. The small white maggots that emerge from the eggs feed upon a wide range of substances, including both living and dead plant and animal life (fig. 31). Seed-corn maggots' food pref-

erences appear to be the sprouting seed and the seedlings or decaying parts of such plants as beans, corn, peas, and potatoes. Their feeding on potato seed pieces in the soil is accompanied by decay, and the young potato plants are either killed or become so weakened as to reduce the stand of plants and the yield. Apparently the seed-corn maggot always begins feeding on the cut surface of the seed piece or on other exposed areas, as it has never been known to enter through the healthy skin of the tuber.

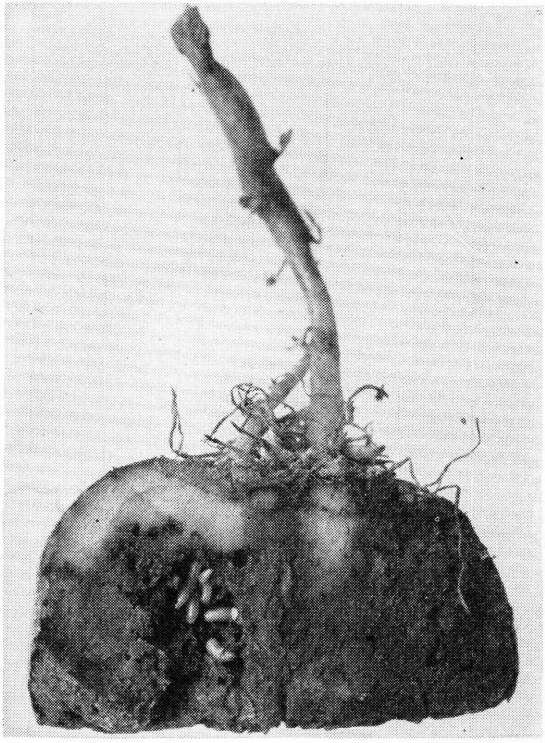

FIGURE 31.—Seed-corn maggots feeding on a potato seed piece.

The best control for the seed-corn maggot is to allow the potato seed piece to heal, or suberize, before it is planted. This requires that the seed pieces be cut 10 days or more before planting. Some growers consider this procedure to be an economic advantage because of the better distribution of labor that it affords. For further information on the control of the seed-corn maggot as a pest of potato seed pieces, see Technical Bulletin 719, entitled "Prevention of Damage by the Seed-Corn Maggot to Potato Seed Pieces."

POTATO LEAFHOPPER

The potato leafhopper (*Empoasca fabae* (Harr.)) is an important pest of potatoes because its feeding on potatoes causes a very destructive diseaselike condition known as hopperburn. This condition begins with a yellowing of the leaf around the margin and tip, followed by a curling upward and rolling inward. The leaf changes in appearance from yellow to brown and then becomes dry and brittle. When the leafhopper infestation is heavy the entire plant may die prematurely.

The potato leafhopper is a small green wedge-shaped insect, about one-eighth of an inch in length. It feeds from the under side of the leaves and sucks the juices of the plant. Leafhoppers are very active, and the first sign of infestation may be detected as one walks through the potato field and the small adults flit from plant to plant as disturbed. The lower surface of the leaves harbors the immature leafhopper, which is similar to the adult in shape but is paler in color and does not have wings.

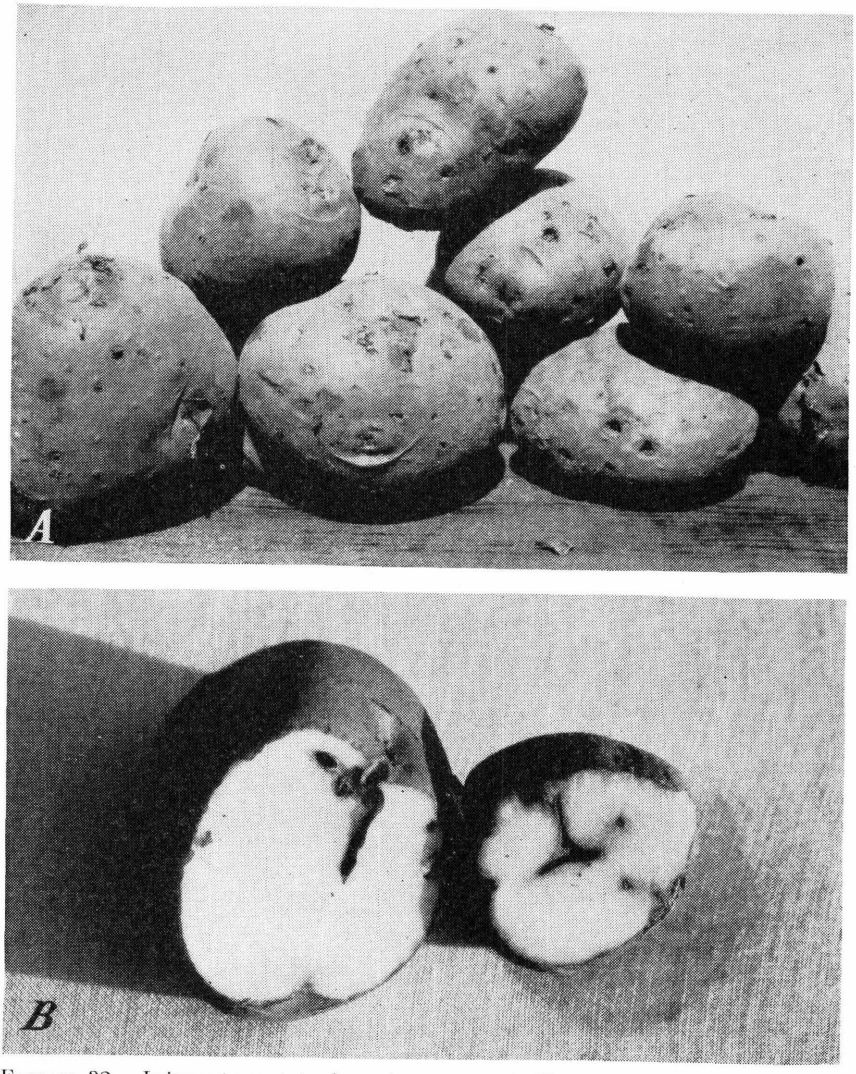

FIGURE 32.—Injury to potato by wireworms: *A*, Typical appearance of small holes on surface of tuber caused by entrance of wireworms; *B*, tuber cut open to show tunnels made by wireworms.

Leafhoppers and the resultant hopperburn can be controlled by spraying with bordeaux mixture (see p. 32) or dusting with copper-sulfate-hydrated-lime dust. The bordeaux mixture should be applied as soon as the adults appear, usually when the plants are 4 to 6 inches high, in areas where the insect is prevalent. Care should be taken to cover the under sides of the leaves with the bordeaux mixture or with the dust mixture.

WIREWORMS AND OTHER SOIL-INFESTING INSECTS

Potato tubers are often rendered unmarketable by small holes caused by the feeding of wireworms or by larvae of the spotted cucum-

ber beetles and flea beetles, while larger scars may be caused by the feeding of white grubs, cutworms, or mole crickets. When the feeding scars are discovered, the insect that caused them is seldom to be found, and it is difficult, therefore, to determine which one of a number of species of insects is responsible. Wireworms cause clean tunnels that are usually perpendicular to the surface of the tuber (fig. 32) and are lined with a new growth of plant tissue. Wireworm tunnels do not contain insect excreta. Tuber worm tunnels extend deeper into the tuber (fig. 30) than those caused by wireworms and are filled with excreta. Flea beetles (see p. 32) cause small pimplelike scars on the tuber and very small tunnels just beneath the skin. White grubs, cutworms, and mole crickets cause large holes that are usually irregular in shape and shallow in depth. Cucumber beetle larvae injure the surface of the tuber in much the same way as wireworms do, but they may leave large scars.

No satisfactory methods have been found for the control of wireworms attacking potatoes in the southern potato-producing regions. Experiments have shown, however, that lands known to be infested by wireworms should be avoided for potato culture and that heaviest wireworm damage occurs usually in fields where potatoes are planted 2 or more years in succession. Some relief from damage to potatoes by the larvae of cucumber beetles may be obtained by planting potatoes in fields following some crop that is not attractive to the cucumber beetle adults.

Mole crickets and cutworms are controlled by applying broadcast over the field a moist mixture of 7½ pounds of sodium fluosilicate and 100 pounds of bran. Sufficient water should be added to the bait to leave it in a crumbly consistency after a handful is pressed in the hand and released. The bait should be applied at the rate of 30 to 40 pounds per acre.

PRODUCTION CENTERS AND VARIETIES GROWN IN THE SEVERAL STATES

In any consideration of varieties in the South, the Federal and State potato-breeding programs are extremely important. It is the purpose of these programs to produce new varieties of potatoes resistant to disease, high yielding, and better adapted to local conditions. These programs are so coordinated that new varieties and seedlings are tested in a number of areas for adaptability to southern conditions.

Several new varieties (Katahdin, Chippewa, Earlaine, Houma, Sebago, Warba, Red Warba, Pontiac, and Sequoia) have already been developed and released through the efforts of the national potato-breeding program. These new varieties are being tested by the State experiment stations to determine their adaptability to local conditions. As new varieties show definite superiority to standard varieties they are released through regular channels for seed-stock production. More detailed information regarding varieties for each State is available through the county agricultural agent or the State agricultural experiment station.

It seems desirable, however, to discuss the varieties commonly grown and other features of potato production in the different production centers of the South.

ALABAMA

The commercial production of early potatoes in Alabama is almost all in Baldwin, Mobile, and Escambia Counties. Triumph is the only variety grown in this area. The potatoes are planted between February 1 and March 15, and harvesting begins about April 10 and continues till about the first of June. In the northern section a fall crop is planted about August 10 and harvested about the middle of November. Triumph and Spaulding Rose are the principal varieties grown in the fall.

ARKANSAS

Potatoes are grown chiefly in the central, southwestern, and south-central parts of Arkansas. The Triumph variety is planted almost entirely for the early and fall crops. Irish Cobbler for the early crops, and McCormick and Green Mountain for the main crop, are also grown to some extent. Early blight is one of the most serious diseases in the State.

DELAWARE

Both a spring and a fall crop of potatoes are grown in Delaware. The spring crop is grown mostly in Sussex County, but some of it is grown in Kent County. Sussex County is the southernmost county and is near the potato districts of the Eastern Shore of Maryland. The fall crop is grown primarily for home use and is distributed throughout the State.

Irish Cobbler is the chief variety planted for the spring crop; Dakota Red (Jersey Redskin) and Green Mountain are used for the fall crop. The spring crop is planted about April 1 and harvested the last of June. The fall potatoes are planted about July 1 and harvested during the first part of October.

Early blight is usually a serious disease of the spring crop in Delaware. Of the virus diseases, leaf roll is the most important. Common scab is of only minor importance.

FLORIDA

Potato production in Florida is confined to three large sections, centering around Hastings in the north, Homestead in the south, and Escambia County in the west. In the northern and western sections about 95 percent of the acreage is planted to Katahdin and Spaulding Rose. Some Triumph, Earlaine, and Irish Cobbler are also planted. In the southern section Triumph is planted almost exclusively, although a small acreage is being planted with Katahdin and Chippewa. The early crop is planted between December 1 and February 10 in the northern and western sections and between September 20 and January 15 in the southern section. Harvesting is done between March 20 and May 20 in the northern and western sections and between February 1 and March 30 in the southern section. Practically all the potatoes shipped from Florida are washed. Late blight is the most serious disease in the potato-producing districts of the State.

GEORGIA

In Georgia, an early crop of potatoes is produced near Savannah, Tifton, and Valdosta. About 90 percent of the acreage is near

Savannah. A later maturing crop is produced in the mountain section in northern Georgia. Irish Cobbler and Triumph are grown in the northern part of the State. Some certified Triumph seed stock is being produced in the mountain section for planting in southern sections. The early crop is planted between January 20 and the last of February and the later crop between March 10 and 20. The early crop is harvested between May 5 and the last of June, whereas the northern crop is not dug until between July 20 and August 1. Early blight and common scab are the most serious diseases of the potato crop in Georgia.

KENTUCKY

About 80 percent of the potatoes raised in Kentucky are grown as a spring crop, which is planted between March 10 and April 10. This crop is harvested during July and the first half of August. A fall crop is grown from the second-grade tubers of the spring crop. These potatoes are planted the last of July or the first part of August and harvested after October 10. Irish Cobblers comprise about 95 percent of the spring crop; the remainder are Triumph, Warba, and Chippewa. Irish Cobbler makes up about the same proportion of the fall crop, other varieties grown being Triumph, Warba, Chippewa, Sebago, Katahdin, and Russet Rural. Mosaics and leaf roll are the most important potato diseases in Kentucky.

LOUISIANA

Potatoes are grown throughout Louisiana. The early crop is grown mostly in the parishes of Terrebonne, Lafourche, St. James, Pointe Coupee, Rapides, West Feliciana, and West Baton Rouge. Planting is done between January 15 and February 15, and the crop is harvested from the middle of April to the middle of May. Triumph is the only variety grown in this section. The practice of washing the crop, although only used to a limited extent at present, is being adopted more generally.

Planting in the remainder of the State is usually done from February 15 to March 10, and the crop is harvested between May 20 and June 10. This crop is grown principally in the southern and central parts of the State. Katahdin is the principal white variety, but some White Rose and Burbank are also planted.

A limited acreage of Triumph and Katahdin is planted to fall potatoes. This crop can be grown successfully only where supplemental water is available. It is planted between August 15 and September 15 and harvested after the first killing frost, which is usually between November 15 and December 1.

Interplanting between sugarcane or corn in 6-foot rows is common in some sections. The potatoes are harvested before the other crop produces much growth. (See cover illustration.[6])

In St. Landry Parish a new practice is becoming established, namely, storing the Katahdin variety in sweetpotato storage houses until August or September, when the local supply is very low.

MARYLAND

Three different crops of potatoes are raised in Maryland. An early crop is grown in the southern and Eastern Shore sections.

[6] By courtesy of F. A. McDaniels.

These potatoes are planted between March 15 and April 15 and are harvested during July. A main crop is grown at the higher elevations in the Allegheny Mountains. Planting is done during the first half of May, and the crop is harvested between August 15 and October 15. The fall crop is planted at lower altitudes during July and the first part of August and harvested between October 20 and November 15. Irish Cobbler is the principal variety planted from the early crop; a limited acreage of Warba, Chippewa, Katahdin, and Earlaine is also grown. In the main crop, Irish Cobbler, Warba, Katahdin, and Chippewa are grown for home use, whereas Rural and Russet Rural are grown on a commercial basis. Dakota Red (Jersey Redskin) is grown extensively for the fall crop.

Corn is extensively interplanted with potatoes for the early crop in the Eastern Shore section. Fusarium wilt and late blight are the most serious diseases in Maryland.

MISSISSIPPI

About the lower one-third of Mississippi produces potatoes on a commercial scale. In the rest of the State potatoes in fields of one-half acre or more are grown primarily for home use. A full crop is produced in the upper two-thirds of the State. Triumph is most generally grown, but the Katahdin is increasing in the late-crop districts. The earliest spring-crop planting is about January 15, and harvesting is done between May 15 and June 15. The fall planting is done between August 15 and September 1, and the crop is harvested between October 20 and November 10. Common scab is rather general in the State, and early blight is prevalent every year in the spring crop.

NORTH CAROLINA

Potatoes are grown principally in two sections in North Carolina. An early crop is produced in the eastern counties, but only a late crop is raised in the western mountainous area.

The early crop is sometimes planted as early as January 25, but usually during February, and it is harvested during June. The late crop in the western counties is planted during the last part of March or the first part of April and is harvested during August and September. A fall crop is grown in a few of the eastern districts. These potatoes are planted during the period from the latter part of July to the first half of August and are harvested during the first half of November.

In the early-producing section, Irish Cobbler and some Triumph, Katahdin, and White Rose are the principal varieties grown. Irish Cobbler and Triumph are raised for the fall crop in this section. The chief varieties grown in the western section are Green Mountain, Irish Cobbler, Katahdin, Chippewa, Burbank, and Sequoia.

Washing is practiced in many of the large grading and packing sheds in eastern North Carolina.

Mosaics and leaf roll are the most serious diseases in the eastern section, whereas late blight, fusarium wilt, and rhizoctonia canker are sometimes serious in the mountain section. Leafhoppers and flea beetles do much damage in the western section.

OKLAHOMA

The commercial production districts of Oklahoma are located in the east-central and southeastern parts of the State. The Triumph is the principal variety grown in these districts, although Irish Cobblers are also grown to some extent. A fall crop is produced in some parts of the State. The early crop is planted during the latter part of February and early in March and harvested during June. The fall crop is planted in June and harvested in September. Early blight and common scab are of only minor importance; virus diseases cause most of the reduction in yield in Oklahoma.

SOUTH CAROLINA

The early potato crop is grown in the coastal counties centering around Charleston. About 90 to 95 percent of the acreage is planted to Irish Cobbler; the remainder of the acreage is planted to Triumph, Green Mountain, Katahdin, and Chippewa. The potatoes are planted during the first part of February and harvested during the last half of May and early in June.

TENNESSEE

The commercial spring crop is grown in the south-central part of Tennessee, centering around Decherd and Columbia. A fall crop is grown throughout the State for home use and local markets. The Triumph and Irish Cobbler varieties are grown in the spring, whereas Triumph and Dakota Red (Jersey Redskin) are grown in the fall. The spring crop is planted during February and March and harvested in June and early July. The fall crop is planted in July and harvested in late October and early November.

TEXAS

Potato production is confined principally to the Brownsville-Los Fresnos and the Eagle Lake-Wharton localities. Within the last few years, however, rather extensive plantings have been made on the sandy loam soils of the upper delta of the Rio Grande. The Triumph variety is planted almost entirely. The Chippewa is increasing in popularity but is primarily a fall variety in this State. The first-grade tubers of the early crop are sold on the market, whereas the second and third grades are held in cold storage for planting the fall crop. About 90 percent of the spring crop and 50 percent of the fall crop are treated with hot formaldehyde for the control of common scab and rhizoctonia canker. Treating is generally done at centrally located points. The spring crop is planted during January and early February and harvested between March 15 and May 15. The fall crop is planted between September 15 and October 15 and harvested in late December and early January.

A relatively new area centering around Hereford is developing in the Panhandle area. This crop is planted for harvest beginning late in the summer and extending into October.

About 80 percent of the crop is sprayed or dusted for the control of diseases and insects. In the early crop, early blight may reduce yields as much as 50 percent during a season when weather conditions

are highly favorable for this disease. Common scab causes heavy losses on the alkaline soils when digging is delayed by untimely rains. All potatoes of the spring crop, except those held for seed purposes, are washed.

VIRGINIA

The most important crop for shipping is the early crop, grown in eastern Virginia. There is a considerable acreage of the late or main crop grown in the central and western parts of the State for home use and for shipment to nearby States. A small acreage of the fall crop is also grown, largely for seed purposes, in eastern Virginia.

The early crop in eastern Virginia is planted between February 15 and March 15 and harvested between June 15 and August 1. The late or main crop in central and western Virginia is planted during May and June and harvested from August 15 to October 15. The fall-crop planting in eastern Virginia is made during the last of July and the first few days of August and is harvested during October and November. Irish Cobbler is planted for all three crops, but to some extent Green Mountain is also planted for the main crop and some Dakota Red (Jersey Redskin) for the fall crop.

Corn is often interplanted between every second row of potatoes at the last cultivation of the early crop. Common scab is the most serious disease in Virginia and is most destructive on excessively limed soils in the spring crop during dry years.

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